Chapter 4

PUMP DRAINAGE IMPROVEMENT

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4.1 Present Condition of Pump Drainage Area

4.1.1 Thanh Da Area

Thanh Da drainage area of about 49.5 ha is triangular in shape surrounded by Thanh Da River to the west and Saigon River to the north and south as shown in Fig. 4.1. The area belongs to Ward 27 of Binh Thanh District. Almost 90% of the area has been developed before 1975 as a residential area consisting of many high storied apartments and some independent houses. Remaining 10% of the area is low-lying and still undeveloped, however, is expected to develop as a residential area in near future, according to the Binh Thanh District. The present population of 17,700 is projected at 20,900 in the target year of 2020.

Systematic drainage pipe network system in Thanh Da area had been constructed before 1975 as sown in Fig. 4.1. The northern part of 20.0 ha from Xo Viet Nghe Tinh Road, of which average ground elevation is about EL.+1.30 m, drains directly into Saigon River through four (4) trunk sewers and has no inundation problem. However, the southern area from this road, in which four (4) main sewers of ø800 to ø1000 mm were constructed, has been flooded at least ten times at the high tide season from September to January every year, due to low ground elevation of EL.+0.90 to EL.+1.20m. Inundation area, depth and duration are surveyed at about 13 ha, 30 to 50 cm and four (4) hours respectively. In the past, one small pumping station had been constructed and operated, however, it was damaged and broken, due to budgetary problem for the sufficient operation and maintenance work. The Petro Viet Nam property situated at southwest part of the area is protected from the external and internal flood by own dike and pump drainage system. According to Binh Thanh District, the undeveloped low-lying area along Thanh Da River is planned to fill up and the gravity discharge system will be applied. Therefore, the southern low-lying are of 15.4 ha is proposed to apply pump drainage system to solve the inundation problems taking into consideration of difficulty of filling up to EL.+2.0 m.

According to the field reconnaissance, many sewers are blocked by garbage, solid disposal and debris, which is one of causes for inundation. Cleaning of the sewer pipes shall be done immediately. Moreover, many houses have been extended over some sewer lines, resulting in difficulty of sufficient operation and maintenance work. Strict land use management including relocation by Binh Thanh District is necessary.

4.1.2 Ben Me Coc (1)

Ben Me Coc (1) drainage area of 70.9 ha belongs to Ward 15 of District 8 located at southwest of the city. The area is rectangular in shape surrounded by Tau Hu, Lo Gom, Ngang No.2/No.3 and Doi canals and is divided into eastern and western parts by the pond as shown in Fig. 4.1. The eastern part of the area (32.6 ha) has been fully developed as warehouse and residential areas without a satisfactory urban development plan and management. Most of the inner city roads are very narrow and secondary and tertiary sewers (ø400 - ø600) have been barely constructed under the narrow streets. On the other hand, the western part of the area is not fully developed yet. Many warehouses and residential houses have been constructed along Lo Gom and Doi canals respectively. Inland areas are used as agricultural land and fishponds. District 8 has plan to develop residential area including some green and open spaces, but no definitive implementation schedule is available yet.

Ben Me Coc (1) area is topographically low with ground level ranging from about EL.+0.9 to EL.+1.3 m. During high tide season from September to January, almost all area has inundated at least ten (10) times per year. No sufficient dike around the area and no water gate at the sewer outlets make inundation more serious. Inundation depth and duration have surveyed at 30 to 50 cm and 4 to 6 hours respectively.

4.1.3 Ben Me Coc (2)

Ben Me Coc (2) drainage area of 46.0 ha is a part of Ward 15 in District 8. As shown in Fig. 4.1, the area is surrounded by Lo Gom, Doi and Ngang No.3 canals, the same as Ben Me Coc (1) area. Even though the area is not so far from Cho Long commercial center and has a potential to develop as a residential area, it is still not fully developed due to insufficient infrastructure services, especially transportation, water supply and drainage system. Almost all houses have been constructed along the ring road but a residential development has recently been progressing towards inland low-lying area by filling up.

Ground elevation of the area is low ranging from EL.+0.9 to EL.+1.3 m. Flood condition of the area is almost the same as that of the western parts of Ben Me Coc (1) area, which has been mentioned before.

4.2 Planning Concept and Design Criteria

(1) Target Year

Target completion year of pump drainage improvement project is set at 2010, the same as canal improvement project. However, all facilities are to be designed to meet the city development plan in 2020.

(2) Design Scale

The design scale for pump equipment and drainage pipe is applied at 5-year and 2-year frequency flood respectively as decided in the Master Plan.

(3) Design Rainfall

(a) For pumping station

Six (6) hours consecutive rainfall with 5-year frequency (R1=70.92 mm, R2=34.04 mm, R3=6.13 mm, R4=1.25 mm, R5=0.79 mm, R6=0.34 mm, Total R=113.47 mm) is applied.

(b) Drainage Pipe

The following rainfall intensity and duration formula with 2-year return period is applied.

$I = 13{,}567/(t^{1.18} + 89)$: $t < 3$ hours

Where, I: point rainfall intensity (mm/hr)
t: duration (minutes)

(4) Design Water Level

Based on the hydraulic analysis in the Master Plan Study, design external water levels at Thanh Da and Ben Me Coc areas are employed as follows:

Location	High Water Level (DHWL)	Mean Water Level (DMWL)	Low Water Level (DLWL)
Thanh Da	+1.32 m	+0.23 m	-2.11 m
Ben Me Coc (1) & (2)	+1.50 m	+0.27 m	-2.12 m

(5) Other Criteria

Other criteria, such as drainage criteria, specific requirement of pump and retarding pond, are the same as that of Master Plan. These are as follows:

- Internal inundation for short duration with very low flood loss shall be allowable for some low lying areas, considering that the project cost will be more reasonable. Duration of pump drainage for design rainfall is proposed to be within 12 hours.

- Specific pump capacity and storage requirement by retarding pond and temporary inundation area are employed at 2.01 $m^3/sec/km^2$ and 69,000 m^3/km^2 respectively.

4.3 Proposed Definitive Plan

4.3.1 Dike Construction

During the high tide season from September to January, Thanh Da, Ben Me Coc (1) and (2) areas have affected about 10 times a year by the external flood from Saigon River, Tau Hu, Lo Gom and Doi canals, due to lower existing bank elevation than DHWL of these canals. Accordingly, a polder dike system is proposed to apply for these areas as the most suitable and economical external flood mitigation measure.

(1) Thanh Da Area

HCMC has constructed dike along Saigon River to protect the proposed pump drainage area of 15.4 ha in Thanh Da from external flood of Saigon River. However, intermediate section of about 75 m has never been provided with any dike, due to difficulty in construction by presence of some illegal houses. New dike construction is proposed for 75m as shown in Fig. 4.2(1/3). The proposed dike, of which top elevation is EL.+2.00 m, is of the same type as that of the existing one, which uses the concrete piles with 300 x 300 mm in section and 12 m in length connected rigidly by reinforced concrete coupling with 400 x 450 mm in section. Bank slope is protected from erosion by red soil mat of 20 cm thick, leveling concrete of 10 cm thick and reinforced concrete with 20 cm thick. Foot of the dike is protected by rip rap of 50 cm thick from scoring by flood water. In the Feasibility Study, dike construction of Thanh Da has been proposed to construct in Phase 1 (2000 – 2005).

(2) Ben Me Coc (1) and (2)

At present, the existing ring roads in Ben Me Coc (1) and (2) have two functions, transportation and dike to protect from external flood of Doi, Tau Hu and Lo Gom canals. However, supplemental leveling survey indicates that top elevation of the existing ring roads is 30 to 90 cm lower than the proposed dike of EL.+2.00 m. This is one main reason for the serious external floods from the surrounding canals in high tide season from September to January in every year. New dikes along Tau Hu, Lo Gom and Ngang No.2 and 3 are proposed to construct simultaneously with the canal improvement work as shown in Fig. 3.9(1/4). However, for the time being, temporary dikes as shown in Figs. 4.2(2/3) and (3/3) are proposed to construct along river side of the ring roads taking into the following considerations:

- In the previous Feasibility Study, canal improvements of Tau Hu (Upstream) and Ngang No.1 to No.3 are proposed to implement in Phase 2 (2006 to 2010).
- Doi canal improvement is excluded in the priority project.

The proposed dike with a top width of 2.0 m is protected by reinforced concrete retaining wall to the ring road side and stone masonry with a slope of 1:1.5 to the canal side as shown in Figs. 4.2(2/3) and (3/3). Length of temporary dike is about 3.95 km in Ben Me Coc (1) and 3.33 km in Ben Me Coc (2). Height of the proposed temporary dikes in Ben Me Coc (1) and (2) vary from 0.3 to 0.8 m and from 0.5 to 0.9 m respectively.

4.3.2 Sewer Line Construction

In order to complete the successful drainage pipe network in Thanh Da area, construction of some new sewers to be connected between the existing sewers and pumping station are proposed. In Ben Me Coc (1) and (2) areas, new sewer lines are proposed to construct under the ring road, in order to mitigate flood damages occurring along the ring road and to integrate the existing small outlets of secondary drains. These proposed sewers have been designed to convey a 2-year flood runoff calculated by Rational Method. Finally, the proposed sewer network systems in combination with pumps and retarding ponds have been evaluated against 5-year frequency flood using hydrodynamic simulation model of MOUSE, which will be mentioned later. Details of the proposed sewers and hydrological calculations for the three (3) pump drainage areas are shown in Tables 4.1 and 4.2.

The proposed sewers by each pump drainage area are summarized below:

Area	Sewer Size (mm)	Sewer Length (m)
Thanh Da	ø800 to ø1200	680
Ben Me Coc (1) (East)	ø900 to ø1500	2,450
Ben Me Coc (1) (West)	ø900 to ø1800	2,170
Ben Me Coc (2)	ø600 to ø2000	4,190

The sewer line network for Ben Me Coc (1) and (2) areas remain the same as those of the Feasibility Study. However, for Thanh Da pump drainage system, location of pumping station and sewer line layout to pump pit is revised. Figs. 4.3(1/3) to (3/3) show the sub-catchments for run-off calculations and proposed sewers for the three (3) pump drainage systems respectively. Samples of plan and longitudinal profile for the proposed sewers are shown in Fig. 4.4.

4.3.3 Construction of Pumping Station with Retarding Pond

(1) Design Condition and Criteria

(a) Proposed Pump Drainage System

The proposed pump drainage areas of Thanh Da, Ben Me Coc (1) and (2) are divided into sub-drainage areas based on the following considerations:

- Topography: All areas are low and flat. Ben Me Coc (1) and (2) areas are very long and narrow in shapes, however, Thanh Da is not so slender in shape.
- Urbanization: Thanh Da and the eastern part of Ben Me Coc (1) areas are fully urbanized, however, other areas are not fully developed and have agricultural land or green open space in inland area.
- Pond: Thanh Da and Ben Me Coc (1) areas have suitable pond located at almost centers of the areas to utilize as retarding ponds, however, no pond is found in Ben Me Coc (2) area.
- Land acquisition: Thanh Da and Ben Be Coc (1) areas have not so big problem for land acquisition of pumping stations and retarding ponds, but, for Ben Me Coc (2), it is necessary to get land for these facilities.
- Phasing: Considering the flood condition and existing urbanization, Thanh Da and Ben Me Coc (1) (East) areas are recognized to be urgently improved.

Taking into above considerations, only Ben Me Coc (1) area consists of two (2) pump drainage areas. The other two (2) areas are planned to be consisting of one (1) pump drainage basin. Figs. 4.3(1/3) and (3/3) show the proposed pump drainage systems in combination with dike and sewer network systems.

(b) Hydraulic Requirements of Pumping Station and Retarding Pond

To economize total pump drainage cost by reducing the required pump capacity, each pumping station is proposed to provide with retarding pond. The specific requirements of pump station and the retarding pond are proposed to be 2.1 $m^3/s/km^2$ and 69,000 m^3/km^2 respectively.

Required pump capacity and storage volume of retarding pond are estimated as follows:

$$Q = q \times A$$
$$V = v \times A = Vt + Vr$$

where, Q: required pump capacity (m^3/s)
q: specific requirement of pump capacity (2.1 $m^3/s/km^2$)
v: specific requirement of storage volume (69,000 m^3/km^2)
A: pump drainage area (km^2)
Vt: allowable temporary inundation volume including storage volume of drainage pipe (m^3)
Vr: required storage volume of retarding pond (m^3)

Calculation results are shown in Table 4.3 and are summarized below:

Name of Drainage Area	Area (ha)	Required Pump Capacity (m^3/s)	Required Storage Capacity of Retarding Pond (m^3)
Thanh Da	15.4	0.70	4,000
Ben Me Coc (1) (East)	32.6	0.68	16,700
Ben Me Coc (1) (West)	38.3	0.80	19600
Ben Me Coc (2)	46.0	0.97	23,500

These requirements, ” in combination with the proposed sewer network, will be finally evaluated by hydrodynamic simulation model of “MOUSE”.

(c) Proposed Location

Taking into consideration of sufficient combination with sewer network and pump drainage system and easiness of land acquisition, construction sites of these pumping stations are proposed as follows:

(a) Thanh Da P.S.:	Squatter area (illegally occupied area) between Thanh Da park and Saigon river
(b) Ben Me Coc (1) (East) P.S.:	Outlet of the existing pond for Doi canal, which is almost center of the drainage area
(c) Ben me Coc (1) (West) P.S.:	Same site as Ben Me Coc (1) (East) P.S.
(d) Ben Me Coc (2) P.S.:	Near the temple along Lo Gom canal, which is almost center of the drainage area

Proposed location of each pumping station is shown in Figs. 4.3(1/3) to (3/3).

(2) Preliminary Design of Proposed Pumping Station

(a) Major Mechanical and Electrical Equipment

Design Water Level and Pump Head

Taking into consideration of HWL of the surrounding rivers/canals and minimum ground elevation of the residential areas, DHWL and DLWL of these pumping stations are proposed as follows:

Name of P.S.	Inner side (Land side)		Outer side (River side)	
	DHWL (m)	DLWL (m)	DHWL (m)	DLWL (m)
Thanh Da P.S.	0.90	-1.00	+1.32	-1.10
Ben Me Coc (1) P.S.	0.90	-1.00	+1.50	-1.10
Ben Me Coc (2) P.S.	0.90	-1.00	+1.50	-1.10

Note: 1. DHWL of inner side is planned to be the same as minimum ground elevation of residential area.

2. DLWL of inner side is planned to easily maintain the water level by tidal effect of Saigon River and Doi canal.
3. DHWL and DLWL of outer side are planned to be average of maximum monthly high water level and low water level of Saigon River and Doi canal respectively.

So, the statistic pump head (Hs) and total pump head (Ht) are estimated as follows:

Hs = DHWL (river side) – DLWL (land side)
Ht = Hs + Hl
where, Hl: hydraulic losses of pump equipment, valves and sluice way (m)

Hl is roughly estimated to be 0.60 m for pump facility and 0.60 m for valves and outlet facilities. Therefore, design statistic pump head and total pump head of each pumping station are shown below:

Name of P.S.	Statistic Pump Head (Hs) (m)	Hydraulic Loss Hydraulic Loss	Total Pump Head (Ht) (m)
Thanh Da P.S.	2.32	1.20	3.52
Ben Me Coc (1) P.S.	2.50	1.20	3.70
Ben Me Coc (2) P.S.	2.50	1.20	3.70

Pump Type Alternatives

The conventional pump applied for urban drainage system is generally classified into (i) Mixed Flow Pump, (ii) Axial Flow Pump, (iii) Centrifugal Flow Pump, (iv) Screw Pump and (v) Submersible Pump. Their applicable ranges in total pump head and bore size are summarized below:

Pump Type		Applicable Range in Total Pump Head (m)	Available Pump Diameter (mm)
Mixes Flow Pump	Horizontal	Less than 7 m	Less than ø 2,000
	Vertical	Less than 9 m	Less than ø 4,000
Axial Flow Pump	Horizontal	Less than 3 m	Less than ø 2,000
	Vertical	Less than 5 m	Less than ø 4,600
Centrifugal Flow Pump	Horizontal	Less than 10 m	Less than ø 1,600
	Vertical	Less than 10 m	Less than ø 2,000
Screw Pump		Less than 8 m	Less than ø 3,500
Submersible Motor Pump		Less than 20 m	Less than ø 1,800

In consideration of the above applicable ranges, the following three alternative pump types are considered.

- Alternative I: Vertical Shaft Axial Flow Pump
- Alternative II: Horizontal Shaft Axial Flow Pump
- Alternative III: Submersible Motor Pump

As a result of comparative study among these alternatives shown in Table 4.4, Alternative III, "Submersible Motor Pump" is recommended as the most applicable and economical pump type.

Number of Pump Unit and Its Bore

Considering the most economical point of view and easiness of operation and maintenance, the pump unit number, pump capacity and pump bore for the three (3) pumping stations are proposed as follows:

Pumping Station	Pump Total	Capacity (m^3/s) Unit	Number of Unit	Bore of Pump (mm)
Thanh Da P.S	0.35	0.35	2	ø 400
Ben Me Coc (1) (East) P.S	0.70	0.35	2	ø 400
Ben Me Coc (1) (West) P.S.	0.80	0.80	1	ø 600
Ben Me Coc (2) P.S.	1.05	0.35	1	ø 400
		0.70	1	ø 600

The above pump bore is estimated by the following formula:

$D = 1{,}000 \times (0.1 \sim 0.08) \times Q^{0.5}$ D: Pump bore (mm)
Q: Unit pumping capacity (m^3/min./unit)

Power Source of Pump Operation

The proposed submersible pump is driven by an electric motor. Considering total operation hour of each pumping station of about 200 hours per year, the following two (2) alternatives of power supply are examined to minimize the project cost for electrical works.

- Alternative I: Commercial power source (AC380V x 50Hz)
- Alternative II: Generating unit (AC380V x 50Hz)

As a results of the comparative study shown in Table 4.5, Alternative I is recommended, because of the following aspect;

- Initial and running cost of Alternative I is lower than that of Alternative II.

- Connection with commercial power line is very easy.
- Alternative II may cause environmental deterioration by noise and vibration to the surrounding residents.

The pump power source is supplied from the existing power line of Electric Company located near the proposed sites. Since total required electricity for the pumping stations are small, low voltage incoming power with 380V is suitable. 15KV/380V power transformer will be supplied on the electrical pole. Required transformer capacity of each pumping station is estimated as follows:

Pumping Station	Voltage (KV)	Transformer Capacity (KVA)
Thanh Da P.S.	22/0.38	150
Ben Me Coc (1) P.S.	22/0.38	200
Ben Me Coc (2) P.S.	22/0.38	200

Low voltage with 380V is supplied to low voltage distribution panel which is installed near the pumping units. Main pumping units are operated from main pump panel. Starting of main pumps is made by auto-transformer.

Other Major Equipment

The other major mechanical/electrical equipment to be required for the installation, operation and maintenance works of the pumping stations are listed in Table 4.6.

(b) Civil Works

Soil Condition

Soil investigations at the proposed pumping sites were conducted in the Feasibility Study stage. These are summarized below:

(i) Thanh Da Pumping Station Site

According to the soil survey results at two (2) sites, the sub-soil consists of the following layers:

Layer	Depth (m)	Thickness (m)	Materials	N-Value	Notation
1	1.5 – 19.0	17.5	Very soft, high plasticity, blackish gray organic clay	0 – 1	OH
2	19.0 – 23.0	4.0	Very loose, blackish gray clayey sand	1	SC
3	18.5 – 22.0	3.5	Loose, greenish gray silty clay sand	2 – 4	SMSC
4	22.0 – 30.0	8.0	Stiff, low plasticity, greenish gray, clay w/sand	10 – 25	CL

The characteristics of the sub-soil are as follows:

* Natural Moisture Contents (Wn): 20.0 – 88.7 %
* Specific Gravity (Gs): 2.591 – 2.693
* Liquid Limit (Lw): 21.2 – 80.1 %
* Plastic Limit (PW): 13.6 – 42.2 %
* Wet Density (rt): 1.435 – 2.066 g/cm^3
* Dry Density (rd): 0.765 – 1.721 g/cm^3
* Cohesion (C): 0.056 – 0.061 kg/cm^2

(ii) Ben Me Coc (1) Pumping Station Site

The sub-soil is basically the same as that of Thanh Da site except the depth of expected bearing stratum as shown below:

Layer	Depth (m)	Thickness (m)	Materials	N-Value	Notation
1	0.0 – 18.0	18	Very soft, high plasticity, blackish gray organic clay	0 – 1	OH
2	18.0 – 25.0	7.0	Soft, high plasticity, blackish gray organic clay	2 – 3	OH
3	5.0 – 30.0	5.0	Soft, low plasticity, blackish gray sandy clay	2 – 3	CL

The characteristics of the sub-soil are as follows:

* Natural Moisture Contents (Wn) : 33.8 - 80.7 %
* Specific Gravity (Gs) : 2.590 - 2.635
* Liquid Limit (Lw) : 41.7 - 81.4 %
* Plastic Limit (Pw) : 24.6 - 43.2 %
* Wet Density (rt) : 1.388 - 1.472 g/cm^3

* Dry Density (rd) : 0.821 - 1.056 g/cm^3
* Cohesion (C) : 0.079 - 0.120 kg/cm^2

(iii) Ben Me Coc (2) Pumping Station Site

Sub-soil at the proposed pumping station consist of the following layers:

Layer	Depth (m)	Thickness (m)	Materials	N-Value	Notation
1	0.0 – 25.0	25.0	Very soft, high plasticity, blackish gray organic clay	0 – 3	OH
2	25.0 – 30.0	5.0	Soft, high plasticity, blackish gray organic clay	3 – 4	OH
3	23.5 – 27.5	4.0	Soft, yellow, whitish gray clay with silt	11 – 14	CL
4	22.0 – 23.5 28.0 – 30.0	1.5 2.0	Dense, light brown gray clay sand	12 – 13	SC
5	24.0 – 30.0	6.0	Medium dense, brownish gray graded sand with silt	12 – 16	SW – SM
6	27.5 – 29.0	1.5	Medium dense, brownish gray poorly graded sand with silt	2 –3	CL

The characteristics of the sub-soil are as follows:

* Natural Moisture Contents (Wn): 14.4 - 81.8 %
* Specific Gravity (Gs) : 2.597 - 2.676
* Liquid Limit (Lw) : 26.2 - 78.6 %
* Plastic Limit (Pw) : 15.5 - 41.8 %
* Wet Density (rt) : 1.453 - 1.936 g/cm^3
* Dry Density (rd) : 0.804 - 1.608 g/cm^3
* Cohesion (C) : 0.074 kg/cm^2

Some additional soil investigations are undertaking to obtain more detail soil data and information for detailed design of the proposed facilities. These will be reported in detailed design stage.

<u>Layout of Pumping Station</u>

The proposed pumping stations consist of inlet pits, pump pit, discharge basin, sluice way and related structures. The civil works of these structures are composed of earth works, foundation work, reinforced concrete work, masonry and others. The general layouts of these pumping stations are shown in Figs. 4.5 to 4.7. Considering the priority of project implementation based on the urgency of flood mitigation, these pumping stations will be constructed in the following phasing:

Phase I (2001 - 2005): Thanh Da and Ben Me Coc (1) (East) P.S.
Phase II (2006 - 2010): Ben Me Coc (1) (West) and Ben Me Coc (2) P.S.

Structural drawings of three pumping stations are shown in Figs. 4.8, 4.9, 4.10 and design concept for each component of the facilities is described below:

(i) Inlet Pit

The inlet pit drains stormwater and wastewater from the existing sewer network into the retarding pond and/or pump pit. The pit is constructed with reinforced concrete and designed to provide a sluice gate, which is usually closed and opened before pump operation. Main features of the pit for each pumping station are as follows:

Name of Pumping Station	Inlet Pipe Diameter (mm)	Number of Inlet Pit (nos.)	Sluice Gate	
			Width (m)	Height (m)
Thanh Da P.S.	ø1,000	1	1,000	1,000
	ø1,200	1	1,200	1,200
Ben Me Coc (1) P.S.	ø1,500	1	1,500	1,500
	ø1,800	1	1,800	1,800
Ben Me Coc (2) P.S.	ø1,500	2	1,500	1,500

(ii) Pump Pit

The pump pit is a reinforced concrete substructure for the trash screen and pump equipment. The pump pit is planned to have sufficient width, depth and length not to occur hydraulic loss for pump operation. The top elevation of the pit (pump floor) is designed to be at least 10 cm higher than that of the surrounding area. The bottom elevation of the pump pit is designed to be deeper more than three times of the pump bore from the pump stop level (Lowest Low Water Level: LLWL). As the bearing capacity of sub-soil is not enough for the spread foundation, the pump pit is supported by reinforced concrete pile with section of 300 mm x 300 mm and length of 24.0 m. Main features of pump pit are as follows:

Name of Pumping Station	Number of Pit (nos.)	Width (m)	Depth (m)	Length (m)	Floor Elevation (m above MSL) Top	Bottom
Thanh Da	2	1.5	3.1 - 3.8	7.3	1.6	-1.5 - -2.5
Ben Me Coc (1) (East)	1	2.6	3.6 - 4.3	8.1	1.6	-2.0 - -2.7
Ben Me Coc (1) (West)	1	2.1	3.6 - 4.8	8.1	1.6	-2.0 - -3.2
Ben Me Coc (2)	1	3.6	3.6 - 4.6	8.5	1.6	-2.0 - -3.0

(iii) Pump House

Since all mechanical and electrical equipment are designed as outdoor type with due consideration of economic point of view, no pump house is designed.

(iv) Discharge Basin

The discharge basin to where water is pumped out from pump pit, has a function to convey the pumped water smoothly to sluice way as a surge tank. The discharge basin connecting with pump pit is constructed with reinforced concrete, of which the top elevation is designed to be the same elevation of EL.+2.0 m as that of the proposed dike. The discharge basin has outlet with sluice gate, which is able to change from pump discharge to gravity discharge by opening the sluice gate. In Thanh Da pumping station, the discharge basin connects two sewer lines to drain wastewater from the service area into Saigon River. The discharge basin is also supported by reinforced concrete piles of 300 mmx 300 mm in section and 24.0 m in length.

(v) Sluice Way

The sluice way has a function to convey the pumped water to Saigon river, Doi and Lo Gom canals from the discharge basin. The sluice way having a gate leaf at its outlet is planned to be of reinforced concrete box culvert running through the flood dike. The maximum velocity in culvert is set at about 2.0 m/s. The box culvert is supported by wooden piles of 200 mm in diameter and 6 m in length. The dimensions of the designed sluice way are summarized below:

Name of Pumping Station	Design Discharge (m^3/s)	Cross Section Width (m)	Height (m)	No. of Section	Length (m)
Thanh Da P.S.	4.1	1.4	1.4	1	36.8
Ben Me Coc (1) P.S.	8.0	2.0	2.0	1	31.3

Ben Me Coc (2) P.S.	5.4	1.8	1.8	1	24.0

Note: The size of sluice gate to be installed is the same as the proposed cross section of box culvert.

(vi) Operation and Maintenance Office

An O/M office including store room is proposed to provide with each pumping station. The office is one story building constructed with a reinforced concrete framework and brick wall. Main features of O/M office are mentioned below:

Pumping Station	No. of staff (person)	Width (m)	Length (m)	Height (m)	Area (m^2)
Thanh Da P.S.	4	4.0	10.0	3.5	40.0
Ben Me Coc (1) P.S.	8	5.0	16.0	3.5	80.0
Ben Me Coc (2) P.S.	4	4.0	10.0	3.5	40.0

Typical design of operation and maintenance office is shown in Fig. 4.11.

(3) Preliminary Design of Retarding Pond

Each pumping station is proposed to provide with retarding pond at inlet side to reduce the required pump capacity and to economize total pump drainage cost. Existing ponds in Thanh Da and Ben Me Coc (1) areas are utilized as the retarding pond. However, there is no existing pond to be utilized as retarding pond in Ben Me Coc (2) area. Inland farm land of about 12,400 m^2 adjacent to the planned city road about 200 m away from the proposed pumping station, is proposed by District 8 as a possible site for the retarding pond. There is some houses to be relocated, so land acquisition and house compensation will be required.

The proposed hydraulic requirement of each retarding pond is shown below:

Retarding Pond	DHWL (m)	DLWL (m)	Effective Depth (m)	Pond Area (m^2)	Storage Cap. (m^3)
Thanh Da	+1.00	-1.00	2.00	2,100	4,200
Ben Me Coc (1) (East)	+0.90	-0.20	0.70	19,000	13,300
Ben Me Coc (1) (Total)	+0.90	-1.00	1.90	19,000	36,100
Ben Me Coc (2)	+0.90	-1.00	1.90	12,400	23,560

Note : Ben Me Coc (1) (East) and (Total) mean Phase 1 and Phase 2 requirements respectively.

Layouts and structural design of the proposed retarding ponds are shown in Figs. 4.12, 4.13, 4.14.

(a) Thanh Da Retarding Pond

As mentioned in before, Thanh Da park has been just renovated by Park Company of HCMC. A new pond (about 2,100 m^2) is also renovated which is only half size of the old one. Storage capacity of the new pond is estimated at about 2,000 m^3, which is only 25% of storage volume for the proposed retarding pond. In order to increase the storage capacity up to maximum 50% of the storage requirement proposed in the Feasibility Study, it is proposed that the new pond is to be re-excavate from EL.-0.50 m to EL.-1.5 m (1.0 m depth) without any change of the pond area. Slope protection work by stone masonry with a slope of 1:1 and sidewalk rehabilitation work is necessary due to the re-excavation of 1.0 m depth.

(b) Ben Me Coc (1) Retarding Pond

The existing Ben Me Coc (1) retarding pond is planned to improve in two (2) phases to adjust the storage requirement in each phase. Main works in phase 1 are construction of control gate connecting with reservoir and Lo Gom canal as shown in Fig. 4.15, dredging the pond of almost 5,500 m^3, sodding slope protection of 4,060 m^2 and rehabilitation of sidewalk along the pond including guard fence. Phase 2 works consist of additional dredging up to bed elevation of EL.-1.50 m and slope protection by stone masonry including upgrade work of sidewalk.

(c) Ben Me Coc (2) Retarding Pond

Ben Me Coc (2) Retarding Pond is planned to newly construct at inland agricultural land about 200 m away from the proposed pumping station. The proposed pond forms rectangular in shape with width of 50 m and length of 248 m. Top elevation of the pond is designed at EL.+1.50 m, which is 10 cm higher than that of the surrounding areas. Bed elevation is designed at EL.-1.50 m, 50 cm lower than DLWL. Sidewalk and guard fence is provided around the pond. Slope protection works by stone masonry is also proposed. The pond is connected with proposed pumping station by box culvert with section of 1.80 m x 1.80 m (length: L = 212.5 m), and with sewer network by drainage pipe with diameter of 2,000 mm (length: L = 92.5 m). New road construction (width: B = 5.0 m and 7.0 m, length: L = 500 m and 505 m) is planned to construct the drainage pipe, box culvert, etc. and to maintain the retarding pond.

(4) Landscape

Drainage pumping station sites are located in the residential areas and landscaping of the sites should be considered for their surrounding environs and for provision of aesthetic solution to the community. Each of drainage pumping station would become as a landscaped focal point to such residential areas.

(a) General Landscape Layout Policy

General layout policy of landscape for three pumping station sites is as follows:

Thanh Da P.S: Area surrounding facility shall have a safety and functional buffer spaces for access alley and small plaza for community use.
Ben Me Coc (1) P.S.: Service access space for maintenance shall be considered enough to provide turning allowance for vehicle moving within limited space.
Ben Me Coc (2) P.S.: Space adjacent to facility along new access road shall be furnished plantings with gardening type in harmony with surrounding existing landscape.

(b) Proposed Landscape

Functional flow of access and activity for O/M staffs and vehicles shall be kept in site layout plan. Main access for motor vehicle shall be minimum 4.0m in width and hard surface paving finish, and colored concrete block paving with 2.0m in width shall be installed along with the O/M office for aesthetic consideration. All facility sites shall be enclosed by fence with 2.4 m in height and major gate door shall be minimum 4.0m in width providing enough space for motor vehicle to go in.

Plantings shall be introduced for establishing aesthetic and amicable environmental condition of the facility sites. Medium trees as major objectives shall be introduced for provision of canopy silhouette with seasonal flowering to the vicinity peoples. Some small flowering shrubs shall be also provided for an accent of the planting layout scheme. Along the enclosure fence especially it faces either to the frontage road or the access road, species of flowering shrub, vine and creeper shall be selected and introduced as a hedge planting.

Facility spaces which are without any paving provision shall be furnished with turf grass in general and in some strategic small area, some proper ground cover plants shall be used. So that all the spaces of facility site will be covered with clean and amicable environment condition accordingly.

Fig. 4.16 shows the landscape layout plans for the three drainage pumping station sites.

4.4 Hydraulic Evaluation by Hydrodynamic Simulation Model

4.4.1 Simulation Model

The proposed pump drainage systems for three (3) areas have been evaluated against 5-year return period rainfall event and Design Flood Level condition. Danish Hydraulic Institute's unsteady sewer flow modeling software called "MOUSE" has been used for hydrodynamic simulation. For Ben Me Coc (1) and (2) areas, simulation model remain the same as those of Feasibility Study. However, for Thanh Da area, simulation model is revised due to the following changes:

(a) The retarding pond area has been reduced from 4,050 m^2 to 2,100 m^2.
(b) The pump capacity has been increased from 0.35 m^3/s to 0.35 m^3/s.
(c) The layout of the pumping station has been newly designed.
(d) The diameter of inlet pipe to pump station carrying discharge from the eastern sub-catchments has been changed from ø 900 to ø 1,000.

Runoff hydrographs from the sub-catchments under future land use condition have been generated applying Time-Area Curve method. The main basin parameters, such as sub-catchment area, runoff coefficient and time of concentration are presented in Table 4.1. The proposed drainage layouts are shown in Figs. 4.3(1/3) to (3/3).

Manning's roughness co-efficient of 0.013 has been used for the sewers considering normal concrete condition. A time step varying from 1 to 15 seconds has been applied for hydrodynamic simulation.

4.4.2 Model Cases

Hydrodynamic simulation has been carried out the following three (3) cases:

Case 1	:	Thanh Da pump drainage improvement plan for total area
Case 2	:	Ben Me Coc (1) pump drainage improvement plan has been investigated for two sub-cases
Case 2A	:	Represent drainage improvement plan for East area
Case 2B	:	Represent drainage improvement plan for the total area
Case 3	:	Ben Me Coc (2) pump drainage improvement plan for total area

4.4.3 Simulation Results

As shown in Table 4.7 and Figs. 4.17(1/4) to (4/4), hydrodynamic simulation has given the following findings:

(a) High water level of retarding pond varies from about +0.85 to +0.95, which is almost the same as or lower than minimum ground elevation of residential area.
(b) Pump operation time for one food will very from 4.0 to 4.5 hours.
(c) Maximum temporary inundation depth will vary from 10 to 15 cm.

Therefore, the proposed pump drainage systems are able to cope with a 5-year flood.

4.5 Bill of Quantities

Bill of quantities of Pump Drainage Works is summarized in Tables 4.8, 4.9, 4.10.

TABLE 4.1 FEATURES OF SEWERS IN THE PUMP DRAINAGE AREAS

THANH DA

Drainage Area	Catchment ID	Sub-Catchment		Sewer Dimension			Hydraulic Property		Sewer Invert		Ground Level		Earth Cover	
		ID	Acc. Area (ha)	Length (m)	Diameter (mm)	Slope (‰)	Velocity (m/s)	Discharge (m3/s)	Upstream (EL. m)	Downstream (EL. m)	Upstream (EL. m)	Downstream (EL. m)	Upstream (EL. m)	Downstream (EL. m)
Thanh Da	TD.1	*TD.1-1*	*0.98*	*138*	*1,000*	*1.1*	*1.0*	*0.8*	*-0.50*	*-0.65*	*1.70*	*1.72*	*1.05*	*1.22*
		TD.1-2	*2.09*	*130*	*1,000*	*1.1*	*1.0*	*0.8*	*-0.65*	*-0.80*	*1.72*	*1.67*	*1.22*	*1.32*
	TD.2	TD.2	2.81	147	1,000	1.7	1.2	1.0	-0.65	-0.90	1.72	1.51	1.22	1.26
	TD.3	*TD.3-1*	*1.05*	*73*	*1,000*	*1.3*	*1.1*	*0.9*	*-0.50*	*-0.59*	*1.60*	*1.50*	*0.95*	*0.94*
		TD.3-2	*2.14*	*98*	*1,000*	*1.3*	*1.1*	*0.9*	*-0.59*	*-0.71*	*1.50*	*1.40*	*0.94*	*0.96*
		TD.3-3	*2.68*	*28*	*1,000*	*1.3*	*1.1*	*0.9*	*-0.71*	*-0.75*	*1.40*	*1.55*	*0.96*	*1.15*
		TD.3-4	*2.89*	*41*	*1,200*	*1.3*	*1.2*	*1.4*	*-0.75*	*-0.80*	*1.55*	*1.46*	*0.95*	*0.91*
		TD.3-5	*3.48*	*76*	*1,200*	*1.3*	*1.2*	*1.4*	*-0.80*	*-0.90*	*1.46*	*1.51*	*0.91*	*1.06*
		TD.3-6	*6.64*	*42*	*1,200*	*1.3*	*1.2*	*1.4*	*-0.90*	*-0.95*	*1.51*	*1.53*	*1.06*	*1.13*
	TD.4	TD.4-1	7.66	46	1,200	1.2	1.2	1.4	-1.00	-1.06	1.55	1.50	1.20	1.21
		TD.4-2	7.90	36	1,200	1.2	1.2	1.4	-1.06	-1.10	1.50	1.50	1.21	1.25
		TD.4-3	8.28	84	1,200	1.2	1.2	1.4	-1.10	-1.21	1.50	1.40	1.25	1.26
		TD.4-4	9.89	216		0.0								
		TD.4-5	10.14	56	1,200	1.2	1.2	1.4	-1.21	-1.28	1.40	1.30	1.26	1.23
		TD.4-6	10.37	19	1,200	1.2	1.2	1.4	-1.28	-1.30	1.30	1.30	1.23	1.25
	TD.5	TD.5	0.83	*134* (47 m new)	800	1.1	0.9	0.4	-0.80	-0.95	1.46	1.40	1.31	1.40
	TD.6	*TD.6-1*	*0.99*	*74*	*800*	*1.6*	*1.1*	*0.5*	*-0.65*	*-0.77*	*1.50*	*1.40*	*1.20*	*1.22*
		TD.6-2	3.72	70	1,000	1.7	1.2	1.0	-0.97	-1.09	1.40	1.34	1.22	1.28
		TD.6-3	4.15	38	1,000	1.6	1.2	1.0	-1.09	-1.15	1.34	1.30	1.28	1.30
	TD.7	TD.7	2.44	136	1,000	1.7	1.2	1.0	-0.74	-0.97	1.65	1.40	1.24	1.22
	TD.8	*TD.8-1*	*0.55*	*53*	*1,000*	*1.1*	*1.0*	*0.8*	*-0.60*	*-0.66*	*1.75*	*1.70*	*1.20*	*1.21*
		TD.8-2	*0.91*	*75*	*1,000*	*1.1*	*1.0*	*0.8*	*-0.66*	*-0.74*	*1.70*	*1.65*	*1.21*	*1.24*
		TD.8-3	*1.15*	*45*	*1,000*	*1.1*	*1.0*	*0.8*	*-0.74*	*-0.79*	*1.65*	*1.60*	*1.24*	*1.24*
		TD.8-4	*1.66*	*49*	*1,000*	*1.1*	*1.0*	*0.8*	*-0.79*	*-0.85*	*1.60*	*1.54*	*1.24*	*1.24*
Total				1,904										

BEN ME COC 1

Drainage Area	Catchment ID	Sub-Catchment		Sewer Dimension			Hydraulic Property		Sewer Invert		Ground Level		Earth Cover	
		ID	Acc. Area (ha)	Length (m)	Diameter (mm)	Slope (‰)	Velocity (m/s)	Discharge (m3/s)	Upstream (EL. m)	Downstream (EL. m)	Upstream (EL. m)	Downstream (EL. m)	Upstream (EL. m)	Downstream (EL. m)
East	BM1E.1	BM1E.1-1	3.55	374	1,000	1.0	1.0	0.8	-0.51	-0.88	1.85	1.50	1.21	1.23
		BM1E.1-2	6.38	337	1,200	1.0	1.1	1.2	-1.08	-1.42	1.50	1.40	1.23	1.47
		BM1E.1-3	16.11	281	1,500	1.0	1.3	2.2	-1.72	-2.00	1.40	1.84	1.47	2.19
	BM1E.2	BM1E.2	7.20	382	1,200	1.3	1.3	1.4	-0.92	-1.42	1.70	1.40	1.27	1.47
	BM1E.3	BM1E.3-1	2.87	348	900	1.0	0.9	0.6	-0.41	-0.75	1.85	1.70	1.21	1.40
		BM1E.3-2	10.97	646	1,500	1.0	1.3	2.2	-1.35	-2.00	1.70	1.90	1.40	2.25
	BM1E.4	BM1E.4	4.52	88	1,100	1.3	1.2	1.1	-1.49	-1.60	1.84	1.84	2.08	2.19
West	BM1W.1	BM1W.1-1	3.46	367	900	0.5	0.6	0.4	-0.45	-0.64	1.80	1.70	1.20	1.29
		BM1W.1-2	9.04	464	1,200	0.5	0.8	0.9	-0.94	-1.17	1.70	1.70	1.29	1.52
		BM1W.1-3	15.81											
		BM1W.1-4	23.23	469	1,800	0.5	1.0	2.6	-1.77	-2.00	1.70	1.84	1.52	1.89
	BM1W.2	BM1W.2-1	5.54	467	1,000	1.2	1.1	0.8	-0.75	-1.33	1.80	1.70	1.40	1.88
		BM1W.2-2	10.47	384	1,200	1.2	1.2	1.4	-1.53	-2.00	1.70	1.90	1.88	2.55
Total				4,607										

BEN ME COC 2

Drainage Area	Catchment ID	Sub-Catchment		Sewer Dimension			Hydraulic Property		Sewer Invert		Ground Level		Earth Cover	
		ID	Acc. Area (ha)	Length (m)	Diameter (mm)	Slope (‰)	Velocity (m/s)	Discharge (m3/s)	Upstream (EL. m)	Downstream (EL. m)	Upstream (EL. m)	Downstream (EL. m)	Upstream (EL. m)	Downstream (EL. m)
North	BM2N.1	BM2N.1-1	4.21	542	1,000	1.1	1.0	0.8	-0.50	-1.10	1.91	1.30	1.26	1.25
		BM2N.1-2	2.62	207	800	1.4	1.0	0.5	-0.60	-0.90	1.80	1.30	1.45	1.25
		BM2N.1-3	8.46	250	1,500	1.1	1.2	1.8	-1.60	-1.87	1.30	1.30	1.25	1.52
		BM2N.1-4	2.96	205	900	1.2	1.0	0.6	-1.02	-1.27	1.77	1.30	1.74	1.52
		BM2N.1-5	12.04	116	1,500	1.1	1.3	2.3	-1.87	-2.00	1.30	1.20	1.52	1.55
	BM2N.2	BM2N.2-1	3.66	382	900	1.1	1.0	0.6	-0.35	-0.78	1.90	1.66	1.20	1.39
		BM2N.2-2	8.34	345	1,200	1.1	1.2	1.3	-1.08	-1.46	1.66	1.30	1.39	1.41
		BM2N.2-3	11.95	214	1,500	1.1	1.3	2.4	-1.76	-2.00	1.30	1.20	1.41	1.55
South	BM2S.1	BM2S.1-1	4.71	545	1,000	0.5	0.7	0.5	-0.44	-0.71	1.91	1.70	1.20	1.26
		BM2S.1-2	*2.82*	*250*	*600*	*1.4*	*0.8*	*0.2*	*-0.20*	*-0.56*	*1.77*	*1.80*	*1.22*	*1.61*
		BM2S.1-3	4.29	130	1,000	1.2	1.0	0.8	-0.56	-0.71	1.80	1.70	1.21	1.26
		BMS2.1-4	10.42	254	1,500	0.5	0.9	1.6	-1.21	-1.34	1.70	1.55	1.26	1.24
		BM2S.1-5	2.39	170	800	1.5	1.0	0.5	-0.39	-0.64	1.77	1.55	1.21	1.24
		BM2S.1-6	13.90	158	1,800	0.5	1.0	2.6	-1.64	-1.72	1.55	1.50	1.24	1.27
	BM2S.2	BM2S.2-1	4.54	331	1,000	0.9	0.9	0.7	-0.47	-0.77	1.90	1.60	1.22	1.22
		BM2S.2-2	8.06	171	1,500	0.9	1.2	2.1	-1.27	-1.42	1.60	1.50	1.22	1.27
	BM2S.1+2	BM2S.1&2	21.96	164	2,000	0.5	1.1	3.4	-1.92	-2.00	1.50	1.38	1.27	1.23
Total				4,434										

LEGEND:

TD.1-1	Existing Sewer
TD.2	Proposed Sewer

TABLE 4.2 HYDROLOGIC CALCULATIONS ON SEWERS IN THE PUMP DRAINAGE AREAS

THANH DA

Catchment Identification			Runoff Calculation for Sewer Flow using Rational Method										HD Model Parameters	
Drainage Area	Catchment ID	Sub-Catchment		Catchment Properties						Runoff Calculation (2 Year R.P.)			Sub-Catchment Area (ha)	Time of Concentration (min.)
		ID	Acc. Area (ha)	Runoff Coeff.	T_{inlet} (min.)	V_{flow} (m/s)	L_{flow} (m)	T_{flow} (min.)	$T_{conc.}$ (min.)	Rain Int. (mm/hr)	Red. Fact.	Peak R.O. (m3/s)		
Thanh Da	TD.1	TD.1-1	(ha)	0.8	5	1.0	138	2	7	137	1.0	0.3	0.98	7
		TD.1-2	2.09	0.8		1.0	130	2	9	132	1.0	0.6	1.10	7
	TD.2	TD.2	2.81	0.8	5	1.2	147	2	9	132	1.0	0.8	0.73	7
	TD.3	TD.3-1	1.05	0.8	5	1.1	73	1	6	139	1.0	0.3	1.05	6
		TD.3-2	2.14	0.8		1.1	98	2	8	136	1.0	0.6	1.09	6
		TD.3-3	2.68	0.8		1.1	28	0	8	135	1.0	0.8	0.54	7
		TD.3-4	2.89	0.8		1.2	41	1	9	133	1.0	0.9	0.21	7
		TD.3-5	3.48	0.8		1.2	76	1	10	131	1.0	1.0	0.59	8
		TD.3-6	6.64	0.8		1.2	42	1	10	130	1.0	1.9	0.35	7
	TD.4	TD.4-1	7.66	0.8	5	1.2	46	1	6	140	1.0	2.4	0.18	6
		TD.4-2	7.90	0.8		1.2	36	1	6	139	1.0	2.4	0.24	7
		TD.4-3	8.28	0.8		1.2	84	1	7	136	1.0	2.5	0.38	6
		TD.4-4	9.89	0.8									1.61	7
		TD.4-5	10.14	0.8		1.2	56	1	8	135	1.0	3.0	0.25	6
		TD.4-6	10.37	0.8		1.2	67	1	9	132	1.0	3.1	0.24	6
	TD.5	TD.5	0.83	0.8	5	0.9	134	3	8	136	1.0	0.3	0.83	6
	TD.6	TD.6-1	0.99	0.8	5	1.0	74	1	6	139	1.0	0.3	0.99	6
		TD.6-2	3.72	0.8		1.2	70	1	7	137	1.0	1.1	0.29	6
		TD.6-3	4.15	0.8		1.1	78	1	8	134	1.0	1.2	0.42	7
	TD.7	TD.7	2.44	0.8	5	0.9	136	2	7	136	1.0	0.7	0.78	6
	TD.8	TD.8-1	0.55	0.8	5	1.0	53	1	6	140	1.0	0.2	0.55	7
		TD.8-2	0.91	0.8		1.0	75	1	7	137	1.0	0.3	0.36	6
		TD.8-3	1.15	0.8		1.0	45	1	8	135	1.0	0.3	0.24	6
		TD.8-4	1.66	0.8		1.0	49	1	9	133	1.0	0.5	0.51	7
	Reservoir	Res.		0.5									0.85	8
Total													15.37	

BEN ME COC 1

Catchment Identification			Runoff Calculation for Sewer Flow using Rational Method										HD Model Parameters	
Drainage Area	Catchment ID	Sub-Catchment		Catchment Properties						Runoff Calculation (2 Year R.P.)			Sub-Catchment Area (ha)	Time of Concentration (min.)
		ID	Acc. Area (ha)	Runoff Coeff.	T_{inlet} (min.)	V_{flow} (m/s)	L_{flow} (m)	T_{flow} (min.)	$T_{conc.}$ (min.)	Rain Int. (mm/hr)	Red. Fact.	Peak R.O. (m3/s)		
East	BM1E.1	BM1E.1-1	3.55	0.8	5	1.0	374	6	11	127	1.0	1.0	3.55	9
		BM1E.1-2	6.38	0.8		1.1	337	12	23	105	1.0	1.5	2.83	9
		BM1E.1-3	16.11	0.8		1.3	281	15	38	83	1.0	3.0	2.53	9
	BM1E.2	BM1E.2	7.20	0.8	5	1.2	382	6	11	129	1.0	2.1	7.20	10
	BM1E.3	BM1E.3-1	2.87	0.8	5	0.9	348	6	11	127	1.0	0.8	2.87	9
		BM1E.3-2	10.97	0.8		1.3	646	15	26	99	1.0	2.4	8.10	10
	BM1E.4	BM1E.4	4.52	0.8	5	1.2	88	1	6	139	1.0	1.4	4.52	10
West	BM1W.1	BM1W.1-1	3.46	0.7	5	0.6	367	10	15	120	1.0	0.8	3.46	9
		BM1W.1-2	9.04	0.7		0.8	464	20	34	88	1.0	1.6	5.58	11
		BM1W.1-3	15.81										6.77	9
		BM1W.1-4	23.23	0.7		1.0	469	27	62	62	1.0	2.8	7.42	11
	BM1W.2	BM1W.2-1	5.54	0.7	5	1.1	467	7	12	125	1.0	1.4	5.54	11
		BM1W.2-2	10.47	0.7		1.2	384	13	25	102	1.0	2.1	4.93	10
	BM1W.3	BM1W.3		0.7									3.69	10
	Reservoir	Res.		1.0									1.93	74
Total													70.92	

BEN ME COC 2

Catchment Identification			Runoff Calculation for Sewer Flow using Rational Method										HD Model Parameters	
Drainage Area	Catchment ID	Sub-Catchment		Catchment Properties						Runoff Calculation (2 Year R.P.)			Sub-Catchment Area (ha)	Time of Concentration (min.)
		ID	Acc. Area (ha)	Runoff Coeff.	T_{inlet} (min.)	V_{flow} (m/s)	L_{flow} (m)	T_{flow} (min.)	$T_{conc.}$ (min.)	Rain Int. (mm/hr)	Red. Fact.	Peak R.O. (m3/s)		
North	BM2N.1	BM2N.1-1	4.21	0.7	5	1.0	542	9	14	122	1.0	1.0	4.21	8
		BM2N.1-2	2.62	0.7	5	1.0	207	3	8	134	1.0	0.7	2.62	8
		BM2N.1-3	8.46	0.7		1.2	250	3	12	126	1.0	2.1	1.63	7
		BM2N.1-4	2.96	0.7	5	1.0	205	3	8	134	1.0	0.8	2.96	8
		BM2N.1-5	12.04	0.7		1.3	116	1	13	123	1.0	2.9	0.62	7
	BM2N.2	BM2N.2-1	3.66	0.7	5	1.0	382	7	12	127	1.0	0.9	3.66	10
		BM2N.2-2	8.34	0.7		1.2	345	5	17	116	1.0	1.9	4.68	9
		BM2N.2-3	11.95	0.7		1.3	214	3	19	111	1.0	2.6	3.61	10
South	BM2S.1	BM2S.1-1	4.71	0.7	5	0.7	545	13	18	113	1.0	1.0	4.71	9
		BM2S.1-2	2.82	0.7	5	0.8	250	5	10	130	1.0	0.7	2.82	7
		BM2S.1-3	4.29	0.7		1.0	130	2	12	126	1.0	1.0	1.47	7
		BMS2.1-4	10.42	0.7		0.9	254	5	23	105	1.0	2.1	1.42	7
		BM2S.1-5	2.39	0.7	5	1.0	170	3	8	135	1.0	0.6	2.39	8
		BM2S.1-6	13.90	0.7		1.0	158	3	10	129	1.0	3.5	1.09	7
	BM2S.2	BM2S.2-1	4.54	0.7	5	0.9	331	6	11	128	1.0	1.1	4.54	9
		BM2S.2-2	8.06	0.7		1.2	184	2	13	123	1.0	1.9	3.52	9
	BM2S.1+2	BM2S.1&2	21.96	0.7		1.1	148	3	16	118	1.0	5.0		
Total													45.95	

TABLE 4.3 REQUIRED PUMP CAPACITY STORAGE VOLUME OF RETARDING POND

Item \ Area	Thanh Da	Ben Me Coc (1)			Ben Me Coc (2)
		West	East	Total	
Drainage Area (ha)	15.4	38.3	32.6	70.9	46.0
Specific Pump Capacity (m3/s/km2)	4.6	2.1	2.1	2.1	2.1
Specific Storage Volume (m3/km2)	50,000	69,000	69,000	69,000	69,000
Required Pump Capacity (m^3/s)	0.70	0.80	0.68	1.49	0.97
Required Strage Volume (m^3)	7,700	26,427	22,494	48,921	31,740
(1) Storage Volume of Temporary Inundation (m3)	3,465	6,894	5,868	12,762	8,280
(2) Storage Volume of Retarding Pond (m3)	4,235	19,533	16,626	36,159	23,460
Proposed Retarding Pond Area (m^2)	2,100	19,000	19,000	19,000	12,400
Proposed H.W.L. of Retarding Pond (m above MSL)	1.0	0.9	0.9	0.9	0.9
Proposed L.W.L. of Retarding Pond (m above MSL)	-1.0	-0.2	-0.2	-1.0	-1.0
Effective Storage Depth of Retarding Pond (m)	2.0	1.1	1.1	1.9	1.9
Effective Storage Volume of Retarding Pond (m3)	4,200	20,900	20,900	36,100	23,560

Note: 1. Since storage capacity of Thanh Da retarding pond is limited at max. 4,200 m^2, specific pump capa
shall be increased to 4.6 $m^3/s/km^2$.

2. Almost 15% of pump drainage area including roads and streets is allowed to have temporary inundation at below 15 cm in depth under the non-flood damage condition.

TABLE 4.4 (1/2) COMPARISON OF DRAINAGE PUMP TYPE ALTERNATIVES

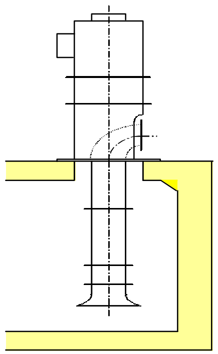
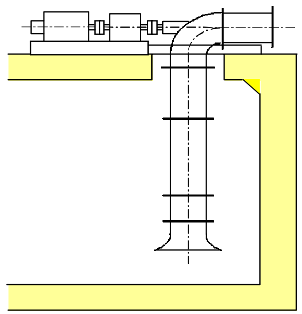
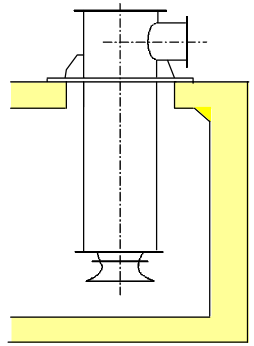
ITEM \ PUMP TYPE	Alternative 1 **Vertical Shaft Axial Flow Pump**	Alternative 2 **Horizontal Shaft Axial Flow Pump**	Alternative 3 **Submersible Motor Pump**
1. Pump Specifications			
Main Pump	Vertical Shaft Axial Flow Pump	Horizontal Shaft Axial Flow Pump	Submersible Motor Pump
Bore x Capacity x Head	ϕ400 x 0.35 [m^3/s] x 3.5 [m]	ϕ500 x 0.35 [m^3/s] x 3.5 [m]	ϕ400 x 0.35 [m^3/s] x 3.5 [m]
Quantity	1	1	1
Revolution	980 [rpm]	700[rpm]	970 [rpm]
Efficiency	80 [%]	81 [%]	80 [%]
Motor	18.5 [kW]	18.5 [kW]	18.5 [kW]
Weight per Unit	2500 [kgf]	1000 [kgf]	600 [kgf] (pump & motor)
2. Installation Layout			
3. Other Equipment			
Discharge Valve	1 (ϕ400 Motor-driven Butterfly)	1 (ϕ500 Motor-driven Butterfly)	None
Flap Valve	ϕ500	ϕ600	ϕ500
Pipe	ϕ500, ϕ600	ϕ500, ϕ600	ϕ400, ϕ500
Electrical Equipment	1 Set (Electrical Panels)	1 Set (Electrical Panels)	1 Set (Electrical Panels)
Crane	1 (Manual, 5 ton)	1 (Manual, 3 ton)	1 (Manual, 1 ton)
Aux. Equipment	None	2 Vacuum Pumps & piping	None
4. Area of Civil and Superstructure	**2** Area of pump room is little smaller than Horizontal shaft model. However, the superstructure is much higher than other types.	**3** Pump room is little larger than others' because of the motor installation. The height of the building is less than half of Vertical shaft pump's.	**4** Both the area of pump room and the height of superstructure is smallest among three.
5. Weight of Pump Facilities	**2** Due to the largest weight of pump itself, the total facility is the heaviest among three.	**3** Intermediate weight.	**4** Although the pump itself is very light comparing others, civil work weight is little less than others
6. Installation of Equipment	**1** The installation requires well trained technicians with special pump installation skills for leveling and shaft alignment.	**2** The installation is easier than vertical type. However, it still requires well trained technicians with special pump installation skills for leveling and shaft alignment.	**5** The installation is the easiest among those three.
7. Operation	**4** Pump can be easily started because impeller is always submerged in the water.	**2** Priming by vacuum pump is necessary when the main pump is started. The starting process, however, can be automated to ease the operation complexity.	**4** Pump can be easily started because impeller is always submerged in the water.
8. Vibration and Noise	**3** Higher vibration and noise are expected than submergible motor pump whose motor is installed under water. The environmental effects are acceptable because the motor is installed on fixed foundation in a closed concrete building while pump is under water.	**2** Higher level of vibration and noise are expected than submergible motor pump whose motor is installed under water. The level is acceptable level because both pump and motor are installed on the fixed foundation in a closed concrete building.	**5** Vibration and noise are the lowest among three because all main components are placed under water.
9. Daily Maintenance	**2** Operating condition is hardly checked directly because most of rotating parts such as pump bearing are submerged in water.	**4** Operating condition can be checked directly because all the rotating components, including the motor, are above the water.	**2** Operating condition cannot be checked directly because all the components, including the motor, are submerged in water.

TABLE 4.4 (2/2) COMPARISON OF DRAINAGE PUMP TYPE ALTERNATIVES

ITEM \ PUMP TYPE	Alternative 1 **Vertical Shaft Axial Flow Pump**		Alternative 2 **Horizontal Shaft Axial Flow Pump**		Alternative 3 **Submersible Motor Pump**	
10. Overhaul	**1**	Overhaul is difficult because vertical shaft with some submerged baring requires special skill and well-trained technicians. Lifting up the pump itself is a lot of work.	**4**	The easiest maintenance ability is expected because both motor and pump is above the water level. Overhaul is easily performed with its horizontal-separate casing structure.	**3**	Overhaul is easy by lifting up the pump and motor unit.
11. Life Span	**4**	Longer device life, comparing with submergible pumps, can be expected because the motor unit is free from suction water contact. By employing some anti-erosion and or non-metal materials, the pump life can be enhanced.	**5**	The longest life among three is expected because both the motor unit and pump itself are always above the suction water level.	**2**	A long life span cannot be expected. Submergible pumps are generally used for short-time or temporally stations. Leakage may occur because motor unit and pump itself are always in the suction water.
12. Reliability	**4**	If the periodically check and maintenance are carried out, long life operation and higher reliability are expected.	**4**	If the periodically check and maintenance are carried out, long life operation and higher reliability are expected.	**2**	Because of possible leakage into the motor unit due to the temperature changes caused by intermittent operation, it has the lowest reliability.
13. Achievements for the Same Type	**5**	There are many cases of adoptions in the past for same type of projects.	**5**	There are many cases of adoptions in the past for same type of projects.	**4**	Although there are some cases of adoption of submersible motor pump for the long-term or permanent pumping stations, there are no or very few examples of the pumping stations with the large-size submersible motor pump treating seawater contamination.
14. Initial Cost 1) Pump and Mechanical Equipment	**2**	Most expensive because of the heaviest and the most complicated pump structure.	**3**	Intermediate. Vacuum pump must be installed in order to prime the main pump when it is started.	**5**	Lowest price.
2) Electrical Equipment	**4**	Same as others'	**3**	Same as others' (Strictly speaking, it costs a couple of percent higher than others because of extra electrical facilities for the priming vacuum pump.)	**4**	Same as Plan 1.
3) Civil and Superstructure	**2**	Most expensive. To reserve enough lift for a crane for maintenance, the superstructure is much higher than others'.	**3**	Intermediate. Due to the motor installation, the superstructure has to be a little larger in longitudinal dimension.	**4**	Least expensive. Thanks for much lighter weight of pump unit, civil cost is reduced comparing with other pumps.
15. Running Cost	**4**	Intermediate energy cost.	**5**	Most efficient in electric energy consumption due to the highest pump efficiency.	**4**	Same as Plan 1.
16. Maintenance Cost	**2**	The highest maintenance cost is predicted because there are many consumable parts.	**4**	The lowest maintenance cost is expected because both motor and pump is above the water level. Overhaul is easily performed with its horizontal-separate casing structure.	**3**	Intermediate maintenance cost.
17. Evaluation	**42**	**Not recommended.** Due to the highest initial cost, this type of pomp is not strongly recommended for a project with limited budget.	**52**	**Not recommended.** With higher reliability, longer life expectancy, and high efficiency in the long run, however initial cost is high including civil cost.	**55**	**Most Recommended.** Although low reliability and short life expectancy, initial cost is lowest. This type should be considered as the first choice for this project.

TABLE 4.5 COMPARISON OF POWER SOURCES OF PUMP OPERATION

Item	Commercial Power Source		Generating Unit	
	Thanh Da	Ben Me Coc (1)	Thanh Da	Ben Me Coc (1)
1. Basic Conditions				
1) Pump motor requirement	18.5kw x 2	18.5kw x 2 45kw x 1	18.5kw x 2	18.5kw x 2 45kw x 1
2) Voltage of motor	AC380V	AC380V	AC380V	AC380V
3) Commercial power	AC380V x 50Hz	AC380V x 50Hz	N.A.	N.A.
4) Estimated operation hours per year	200hrs	200hrs	200hrs	200hrs
2. Equipment List				
(Commercial power)				
1) H.V. incoming unit	1	1	N.A.	N.A.
2) Transformer	150kVA x 1	200kVA x 1	N.A.	N.A.
3) L.V. distribution and starter panel	2	3	N.A.	N.A.
(Generating unit)				
1) Generating unit	N.A.	N.A.	100kVA x 1	200kVA x 1
2) L.V. distribution and starter panel	N.A.	N.A.	2	3
3) Oil tank (72hrs)	N.A.	N.A.	2100 litre x 1	3400 litre x 1
3. Comparison				
3-1 O&M etc.				
1) Operation	Starting can be made anytime.		Before operation, starting of engine generating unit is required.	
2) Maintenance	Maintenance for major electrical parts is required.		Periodical overhaul of engine and generating unit is required.	
3) Reliability	Good		Good	
4) Noise & vibration	No noise and vibration are expected.		Noise and vibration are expected from engine.	
5) Required space	15 m2	21 m2	35 m2	45 m2
3-2 Cost comparison (Unit: Million VND)				
1) Initial cost (M&E)	12,594.20	25,413.70	12,980.00	33,810.00
2) Running cost				
-Basic charge	0	0	-	-
-Running charge (per year)	18.5kw x 2 x 200hrs x 1463VND/kw/hr = 10.83	(18.5kw x 2 + 45kw x 1) x 200hrs x 1463VND/ kw/hr = 23.99	28 litre/hr x 200hrs x 3,666VND/litre = 20.53	46 litre/hr x 200hrs x 3,666VND/litre = 33.73
Running cost total	10.83	23.99	20.53	33.73

TABLE 4.6 MAIN EQUIPMENT LIST

1. Mechanical equipment

Equipment name	Thanh Da P.S.		Ben Me Coc (1) P.S.		Ben Me Coc (2) P.S.	
Main pump (1)	0.35m3/s x 3.52m 400mm dia. (18.5kw)	2	0.35m3/s x 3.7m 400mm dia. (18.5kw)	2	0.35m3/s x 3.7m 400mm dia. (18.5kw)	1
Main pump (2)			0.80m3/s x 3.7m 600mm dia. (45kw)	1	0.7m3/s x 3.7m 600mm dia. (37kw)	1
Flap valve (1)	600mm dia.	2	600mm dia.	2	600mm dia.	1
Flap valve (2)			800mm dia.	1	800mm dia.	1
Pipe (1)	400 to 600mm dia.	2	400 to 600mm dia.	2	400 to 600mm dia.	1
Pipe (2)			600 to 800mm dia.	1	600 to 800mm dia.	1
Bar screen (1)	1500mm W x 3100mm H	2	2600mm W x 3600mm H	1	3600mm W x 3600mm H	1
Bar screen (2)			2100mm W x 3600mm H	1		
Stoplog(1)	1500mm W x 3100mm H	2	2600mm W x 3600mm H	2	3600mm W x 3600mm H	2
Stoplog(2)			2100mm W x 3600mm H	1	2000mm W x 3600mm H	1
Inlet gate (1)	1200mm W x 1200mm H	1			1500mm W x 1500mm H	1
Inlet gate (2)	1000mm W x 1000mm H	1				
By-pass gate	1400mm W x 1400mm H	1	1500mm W x 1500mm H	1	1500mm W x 1500mm H	1
Flap gate (1)	1000mm dia.	1	1500mm dia.	1	1500mm dia.	2
Flap gate (2)	1200mm dia.	1	1800mm dia.	1		
Outlet gate (1)	1400mm W x 1400mm H	1	1800mm W x 1800mm H	1	1800mm W x 1800mm H	1
Outlet gate (2)			2000mm W x 2000mm H	3		

2. Electrical equipment

Equipment name	Thanh Da P.S.		Ben Me Coc (1) P.S.		Ben Me Coc (2) P.S.	
H.V. incoming	AC22kV x 50Hz x 3phase Outdoor	1	AC22kV x 50Hz x 3phase Outdoor	1	AC22kV x 50Hz x 3phase Outdoor	1
Transformer	AC22kV/380V x 150kVA Outdoor	1	AC22kV/380V x 200kVA Outdoor	1	AC22kV/380V x 200kVA Outdoor	1
L.V. distribution panel	AC380V x 50Hz x 3phase Outdoor	1	AC380V x 50Hz x 3phase Outdoor	1	AC380V x 50Hz x 3phase Outdoor	1
Main pump panel	AC380V x 50Hz x 3phase Outdoor	1	AC380V x 50Hz x 3phase Outdoor	2	AC380V x 50Hz x 3phase Outdoor	2
Water level gauge	Bellows type	2	Bellows type	2	Bellows type	2
Cable		1		1		1

TABLE 4.7 HYDRODYNAMIC SIMULATION RESULTS FOR THE PUMP DRAINAGE SYSTEMS

Model Cases		Drainage Systems				Pump Characteristics				Reservoir Characteristics		
Case	Sub-Case	Name	Category	Area		Capacity	Start	Stop	Operation	Area	Initial (Low)	Maximum (High)
				Sub-Drainage (ha)	Total (ha)	(m3/s)	Level* (EL. m)	Level** (EL. m)	Time (hr:mm)	(m2)	Water Level (EL. m)	Water Level (EL. m)
1	1	Thanh Da	Phase I	15.37	15.37	0.70	-0.80	0.80	4:12	2,100	-1.00	1.02
2	2A	Ben Me Coc 1 - East	Phase I	32.57	70.92	0.70	0.00	0.80	3:57	19,000	-0.20	0.83
	2B	Ben Me Coc 1 - East + West	Phase II (including Phase I)	70.92		1.50	-0.80	0.80	4:03	19,000	-1.00	0.95
3	3	Ben Me Coc 2 - North + South	Phase I	45.95	45.95	1.05	-0.80	0.80	4:12	12,375	-1.00	0.85

* : Refers to internal water level at reservoir.
** : Refers to external water level at outlet.

Note :
- For all cases, 5-year rainfall as derived from Mass Curve analysis has been applied.
- For Thanh Da, at the outlets, dynamic water level with crest level of EL. +1.32 m has been applied.
- For Ben Me Coc 1 and 2, at the outlets, dynamic water level with crest level of EL. +1.50 m has been applied.
- Flap gates (non-return valves) have been set up at all the outlets.

TABLE 4.8 BILL OF QUANTITIES FOR PUMP DRAINAGE IMPROVEMENT (DIKE CONSTRUCTION)

Item	Unit	Thanh Da (L = 75 m)			Ben Me Coc (1)			Ben Me Coc (2)			Total		
		Phase I	Phase II	Sub-total	Phase I	Phase II	Sub-total	Phase I	Phase II	Sub-total	Phase I	Phase II	Total
1. Earth Work													
(1) Excavation	m^3	203	0	203	10,100	0	10,100	8,120	0	8,120	18,423	0	18,423
(2) Backfill	m^3	0	0	0	4,950	0	4,950	3,890	0	3,890	8,840	0	8,840
(3) Surplus Soil	m^3	203	0	203	5,150	0	5,150	4,230	0	4,230	9,583	0	9,583
(4) Filling	m^3	0	0	0	2,410	0	2,410	2,660	0	2,660	5,070	0	5,070
2. Foundation Work													
(1) RC Pile (300x300x12)	nos.	52	0	52	0	0	0	0	0	0	52	0	52
(2) RC Pile (250x250x12)	nos.	0	0	0	0	0	0	0	0	0	0	0	0
(3) Wooden Pile	nos.	0	0	0	0	0	0	0	0	0	0	0	0
(4) Sand Mat (t=20 cm)	m^3	92	0	92	580	0	580	525	0	525	1,197	0	1,197
(5) Rip Rap (t=50 cm)	m^3	190	0	190	0	0	0	0	0	0	190	0	190
3. Concrete Work													
(1) Leveling Concrete (180 kg/cm^2)	m^3	46	0	46	195	0	195	175	0	175	416	0	416
(2) Reinforced Concrete (210 kg/cm2)	m^3	113	0	113	1,400	0	1,400	1,295	0	1,295	2,808	0	2,808
4. Stone Masonry													
(1) Sodding Protection (S = 1: 2.0)	m^2	0	0	0	0	0	0	0	0	0	0	0	0
(2) Stone Masonry (S = 1: 1.5)	m^2	0	0	0	7,000	0	7,000	6,000	0	6,000	13,000	0	13,000
(3) Stone Masonry (S = 1: 0.5)	m^2	0	0	0	0	0	0	0	0	0	0	0	0
5. Pavement													
(1) O /M Road (Grade V)	m^2	394	0	394	0	0	0	0	0	0	394	0	394
(2) Concrete Block (t = 10 cm)	m^2	0	0	0	7,400	0	7,400	6,000	0	6,000	13,400	0	13,400
(3) Mortal (t = 5 cm)	m^3	0	0	0	390	0	390	315	0	315	705	0	705

Note: All dikes of Phase 1 Project in Ben Me Coc (1) and (2) are proposed to apply the temporary type. The permanent dikes along Tau Hu (Upstream) including Lo Gom, and Ngang No.1 to No.3 canals will be constructed in Phase 2 Canal Improvement Project.

TABLE 4.9 BILL OF QUANTITIES FOR PUMP DRAINAGE IMPROVEMENT (SEWER LINE CONSTRUCTION)

THANH DA

Drainage Area	Sewer Pipe				Manhole	
	Diameter	Length			Type	Number
		Segment	Total	Unit		
	(m)	(m)	(m)	(Nos.)		(Nos.)
Thanh Da	800	47	47	1	3	1
	1,000	73, 74, 70, 38, 62, 74	391	6	4	9
	1,200	46, 36, 84, 56, 19	241	5	4	9
Total			679	12		19

BEN ME COC 1

Drainage Area	Sewer Pipe				Manhole	
	Diameter	Length			Type	Number
		Segment	Total	Unit		
	(m)	(m)	(m)	(Nos.)		(Nos.)
Ben Me Coc 1	900	60, 60, 60, 60, 54, 54, 72, 55, 60, 60, 60, 60	715	12	3	12
	1,000	63, 65, 78, 84, 84, 100, 100, 100, 83, 84	841	10	4	10
	1,100	88	88	1	4	1
	1,200	100, 100, 68, 69, 100, 100, 91, 91, 100, 100, 100, 82, 82, 100, 100, 100, 84	1,567	17	4	17
	1,500	100, 100, 81, 100, 100, 100, 100, 100, 73, 73	927	10	5	12
	1,800	100, 100, 100, 84, 85	469	5	6	6
Total			4,607	55		58

BEN ME COC 2

Drainage Area	Sewer Pipe				Manhole	
	Diameter	Length			Type	Number
		Segment	Total	Unit		
	(m)	(m)	(m)	(Nos.)		(Nos.)
Ben Me Coc 2	800	60, 60, 43, 44, 60, 60, 50	377	7	3	6
	900	60, 60, 42, 43, 60, 60, 60, 60, 54, 44, 44	587	11	3	11
	1,000	77, 88, 88, 63, 82, 78, 66, 56, 91, 70, 70, 86, 86, 86, 65, 65, 100, 100, 65, 66	1,548	20	4	20
	1,200	100, 100, 72, 73	345	4	4	4
	1,500	83, 83, 84, 60, 56, 70, 70, 74, 85, 85, 84, 85, 86	1,005	13	5	15
	1,800	79,79	158	2	6	2
	2,000	82,82	164	2	6	3
Total			4,184	59		61

TABLE 4.10 (1/2) BILL OF QUANTITIES FOR PUMP DRAINAGE IMPROVEMENT (PUMPING STATION, CONTROL GATE, RETARDING POND)

Item	Unit	Thanh Da			Ben Me Coc (1)			Ben Me Coc (2)			Total		
		Phase I	Phase II	Sub-total	Phase I	Phase II	Sub-total	Phase I	Phase II	Sub-total	Phase I	Phase II	Total
A. Pumping Station with Sluice Way													
1. Earth Work													
(1) Sheathing	m^2	610	0	610	0	0	0	0	1,336	1,336	610	1,336	1,946
(2) Excavation	m^3	1,655	0	1,655	1,880	230	2,110	0	5,020	5,020	3,535	5,250	8,785
(3) Backfill	m^3	605	0	605	1,220	120	1,340	0	3,260	3,260	1,825	3,380	5,205
(4) Surplus Soil	m^3	1,050	0	1,050	660	110	770	0	1,760	1,760	1,710	1,870	3,580
(5) Filling	m^3	55	0	55	410	0	410	0	870	870	465	870	1,335
2. Foundation Work													
(1) RC Pile (300x300x24)	nos.	20	0	20	16	18	34	0	25	25	36	43	79
(2) RC Pile (250x250x12)	nos.	0	0	0	0	0	0	0	0	0	0	0	0
(3) Wooden Pile (dia. 200, L= 6.0 m)	nos.	3,080	0	3,080	3,830	0	3,830	0	3,803	3,803	6,910	3,803	10,713
(4) Sand Mat (t=20 cm)	m^3	70	0	70	60	22	82	0	136	136	130	158	288
(5) Rip Rap (t=50 cm)	m^3	30	0	30	73	24	97	0	25	25	103	49	152
3. Concrete Work													
(1) Leveling Concrete (180 kg/cm^2)	m^3	35	0	35	30	11	41	0	68	68	65	79	144
(2) Reinforced Concrete (210 kg/cm2)	m^3	283	0	283	272	130	402	0	442	442	555	572	1,127
4. O/M Office													
(1) Building (Rainforced Concrete)	m^2	40	0	40	90	0	90	0	40	40	130	40	170
(2) Gard Fence (Steel Net, H=2.4 m)	m	120	0	120	90	0	90	0	120	120	210	120	330
(3) Landscaping (Paving)	m^2	180	0	180	210	0	210	0	160	160	390	160	550
(4) Landscaping (Planting)	m^2	110	0	110	210	0	210	0	470	470	320	470	790
5. O/M Road													
(1) Road Construction (Grade V)	m^2	360	0	360	120	0	120	0	120	120	480	120	600
(2) Low Cost Pavement	m^2	155	0	155	0	0	0	0	0	0	155	0	155
B. Control Gate													
1. Earth Work													
(1) Sheathing	m^2	0	0	0	0	0	0	0	0	0	0	0	0
(2) Excavation	m^3	0	0	0	605	0	605	0	0	0	605	0	605
(3) Backfill	m^3	0	0	0	475	0	475	0	0	0	475	0	475
(4) Surplus Soil	m^3	0	0	0	130	0	130	0	0	0	130	0	130
(5) Filling	m^3	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 4.10 (2/2) BILL OF QUANTITIES FOR PUMP DRAINAGE IMPROVEMENT (PUMPING STATION, CONTROL GATE, RETARDING POND)

Item	Unit	Thanh Da			Ben Me Coc (1)			Ben Me Coc (2)			Total		
		Phase I	Phase II	Sub-total	Phase I	Phase II	Sub-total	Phase I	Phase II	Sub-total	Phase I	Phase II	Total
2. Foundation Work													
(1) RC Pile (300x300x24)	nos.	0	0	0	0	0	0	0	0	0	0	0	0
(2) RC Pile (250x250x12)	nos.	0	0	0	0	0	0	0	0	0	0	0	0
(3) Wooden Pile	nos.	0	0	0	1075	0	1,075	0	0	0	1,075	0	1,075
(4) Sand Mat (t=20 cm)	m^3	0	0	0	17	0	17	0	0	0	17	0	17
(5) Rip Rap (t=50 cm)	m^3	0	0	0	55	0	55	0	0	0	55	0	55
3. Concrete Work													
(1) Leveling Concrete (180 kg/cm^2)	m^3	0	0	0	8	0	8	0	0	0	8	0	8
(2) Reinforced Concrete (210 kg/cm2)	m^3	0	0	0	94	0	94	0	0	0	94	0	94
4. Slope Protection													
(1) Sodding Protection (1:2.0)		0	0	0	0	0	0	0	0	0	0	0	0
(2) Stone Masonry (1:1.0)	m^2	0	0	0	173	0	173	0	0	0	173	0	173
(3) Stone Masonry (1:0.5)	m	0	0	0	107	0	107	0	0	0	107	0	107
C. Retarding Pond													
1. Earth Work													
(1) Sheathing	m^2	0	0	0	0	0	0	0	0	0	0	0	0
(2) Excavation	m^3	2,200	0	2,200	5,590	18,510	24,100	0	53,000	53,000	7,790	71,510	79,300
(3) Backfill	m^3	0	0	0	0	120	120	0	0	0	0	120	120
(4) Surplus Soil	m^3	2,600	0	2,600	5,590	110	5,700	0	53,000	53,000	8,190	53,110	61,300
(5) Filling	m^3	0	0	0	1,700	0	1,700	0	870	870	1,700	870	2,570
(6) Demolish of Existing Slope Protection	m^3	400	0	400	0	0	0	0	0	0	400	0	400
2. Slope Protection													
(1) Sodding Protection (1:2.0)	m^2	0	0	0	4,060	0	4,060	0	0	0	4,060	0	4,060
(2) Stone Masonry (1:1.0)	m^2	1,450	0	1,450	0	0	0	0	2,140	2,140	1,450	2,140	3,590
(3) Stone Masonry (1:0.5)	m^2	0	0	0	150	3,130	3,280	0	0	0	150	3,130	3,280
(4) Side Ditch (B = 2.0 m, H = 0.25 m)	m	0	0	0	0	0	0	0	90	90	0	90	90
3. O/M Road	m^2												
(1) Road Construction (Grade V)	m^2	0	0	0	0	0	0	0	4,760	4,760	0	4,760	4,760
(2) Low cost pavement	m^2	0	0	0	900	0	900	0	0	0	900	0	900
(3) Concrete Block Pavement	m^2	340	0	340	0	900	900	0	910	910	340	1,810	2,150
(4) Steel Bar Gard Fence (H = 2.4 m)	m	0	0	0	1,000	0	1,000	0	470	470	1,000	470	1470

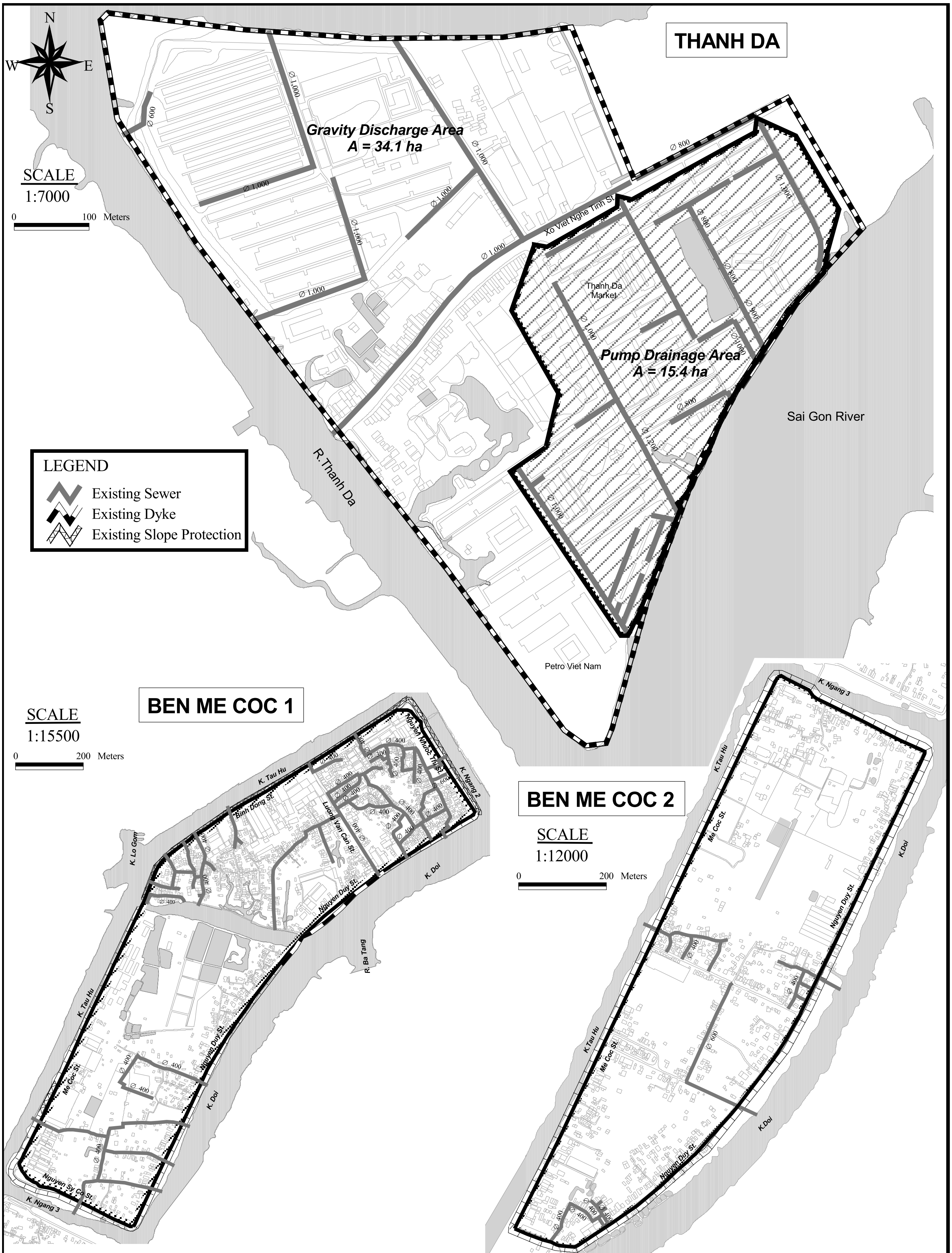
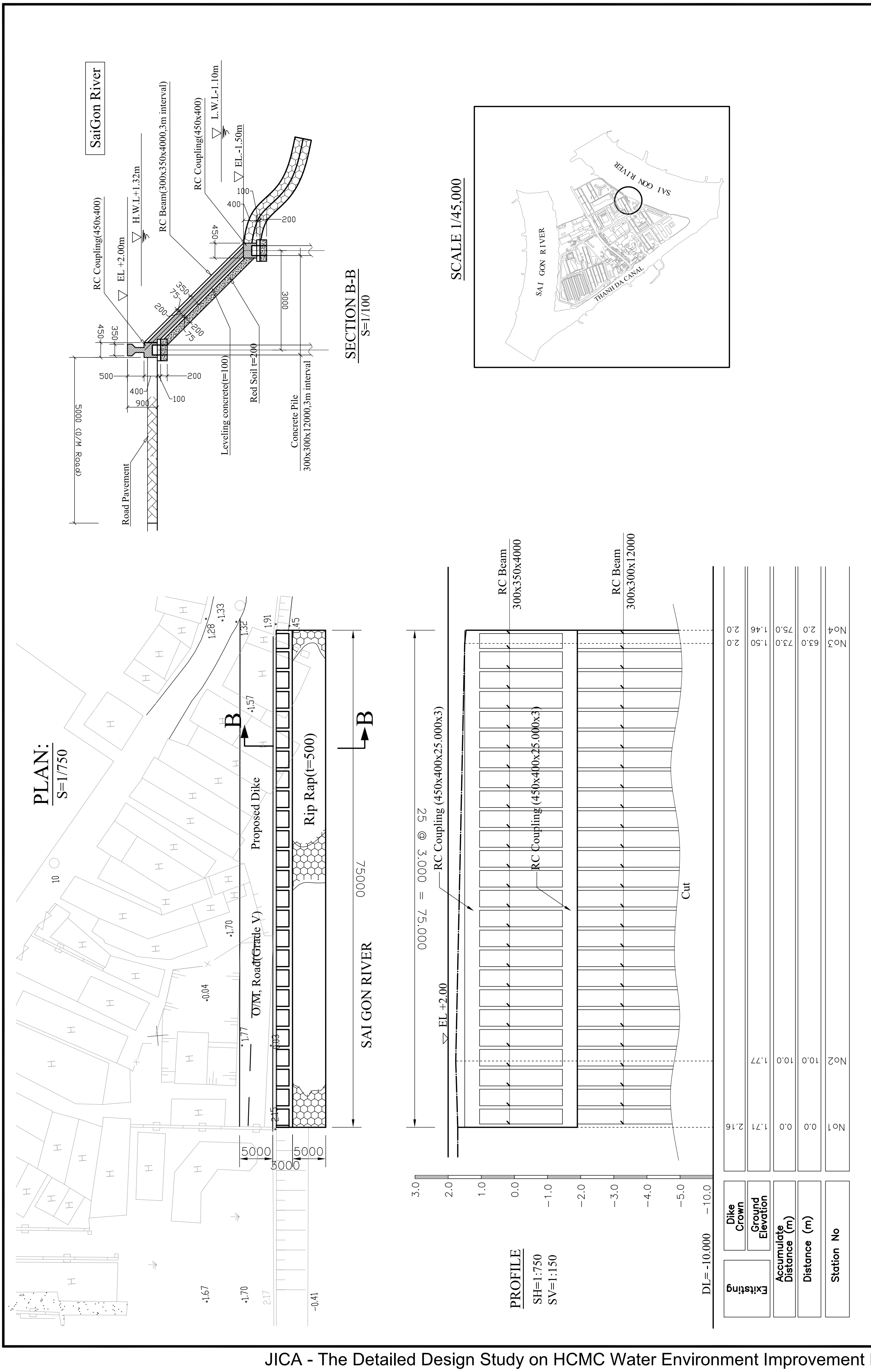


FIG. 4.1 EXISTING SEWER NETWORKS IN THE PRIORITY PROJECT AREAS

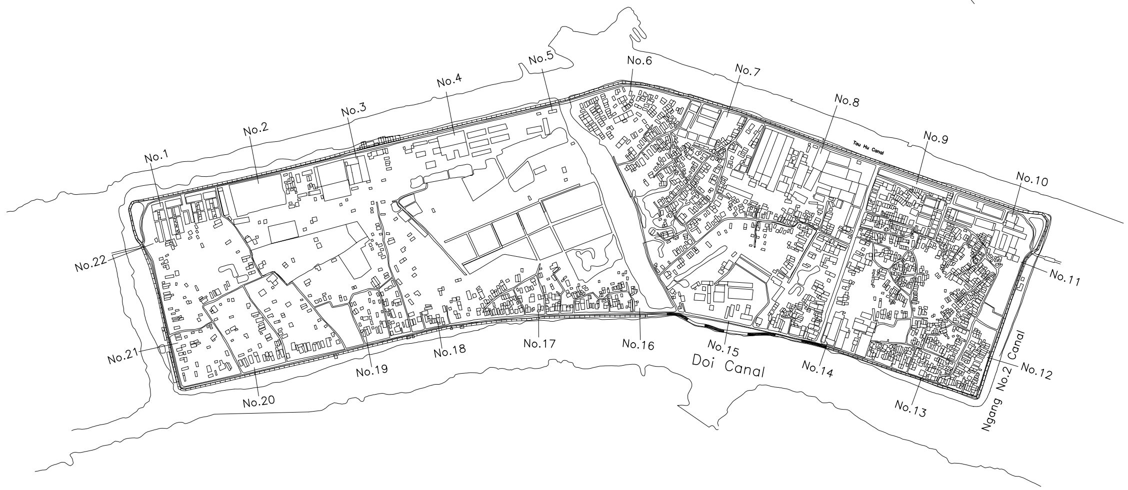


Existing	No1	No2	No3	No4
Dike Crown	2.16		2.0	2.0
Ground Elevation	1.71	1.77	1.50	1.46
Accumulate Distance (m)	0.0	10.0	73.0	75.0
Distance (m)	0.0	10.0	63.0	2.0
Station No	No1	No2	No3	No4

FIG. 4.2(1/3) PROPOSED DIKE CONSTRUCTION (THANH DA AREA)

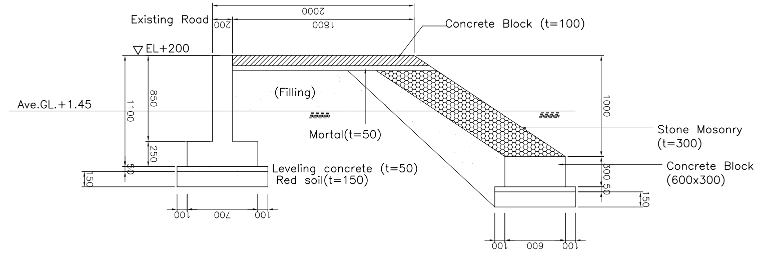
PLAN

Scale 1/15,000



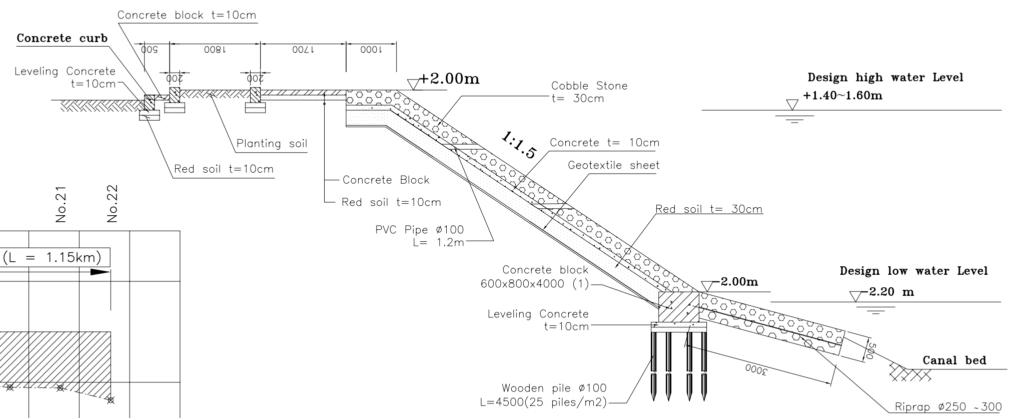
TYPICAL CROSS SECTION OF TEMPORARY DIKE CONSTRUCTION IN PHASE 1 PROJECT

(Scale 1/75)



TYPICAL CROSS SECTION OF PERMANENT DIKE ALONG TAU HU, LOGOM, NGANG NO.2 AND NO.3 CANALS CONSTRUCTION IN PHASE 2 PROJECT

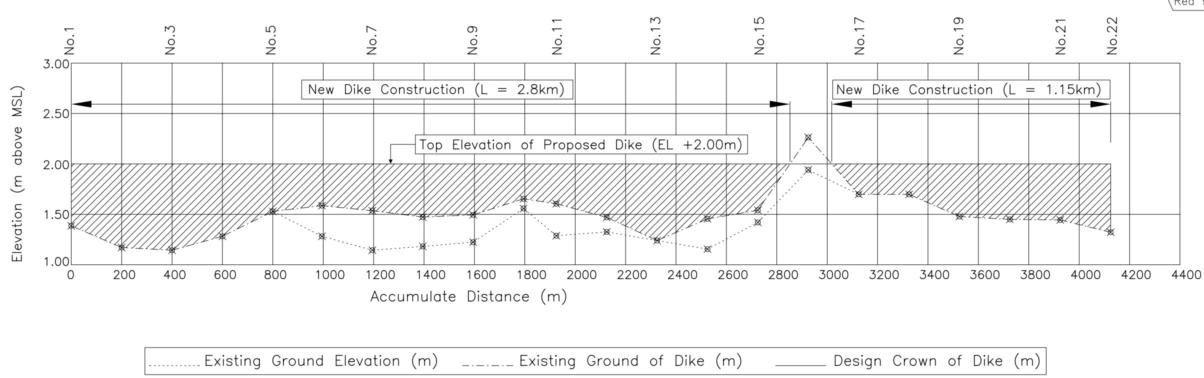
(Scale 1/150)



LONGTUDINAL PROFILE OF PROPOSED DIKE

Scale Horizontal: 1/30,000

Vertical: 1/75



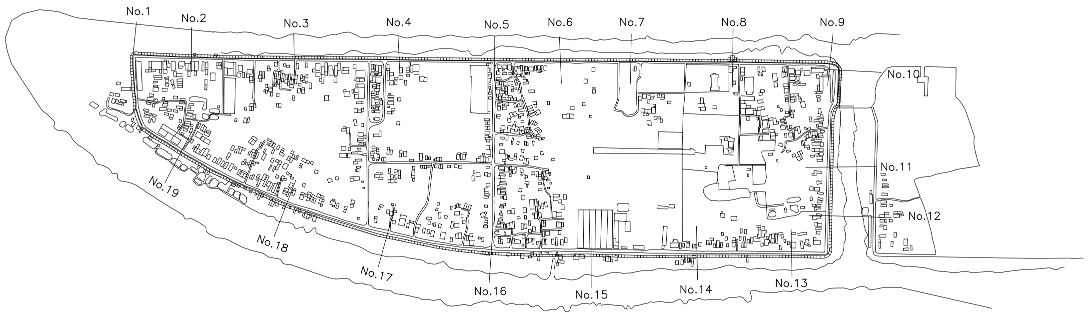
Note:

1. Temporary dike should be constructed along the ring road in phase 1 project
2. Permanent dike along Tau Hu, Lo Gom, Ngang No.2 and No.3 canals should be simultaneously with canal improvement works in phase 2 project

FIG. 4.2(2/3) PROPOSED DIKE CONSTRUCTION (BEN ME COC (1) AREA)

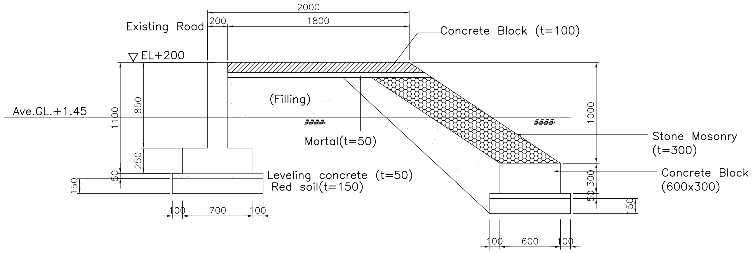
PLAN

S= 1/15,000



TYPICAL CROSS SECTION OF TEMPORARY DIKE CONSTRUCTION IN PHASE 1 PROJECT

(Scale 1/75)



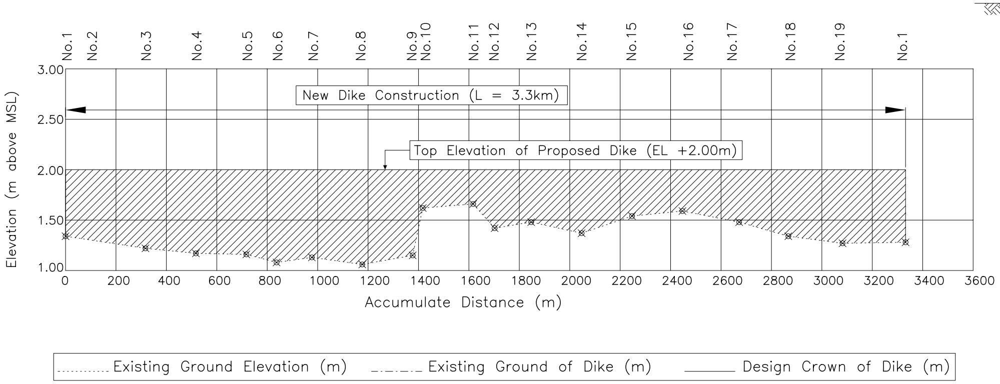
TYPICAL CROSS SECTION OF PERMANENT DIKE ALONG LOGOM AND NGANG NO.3 CANALS CONSTRUCTION IN PHASE 2 PROJECT

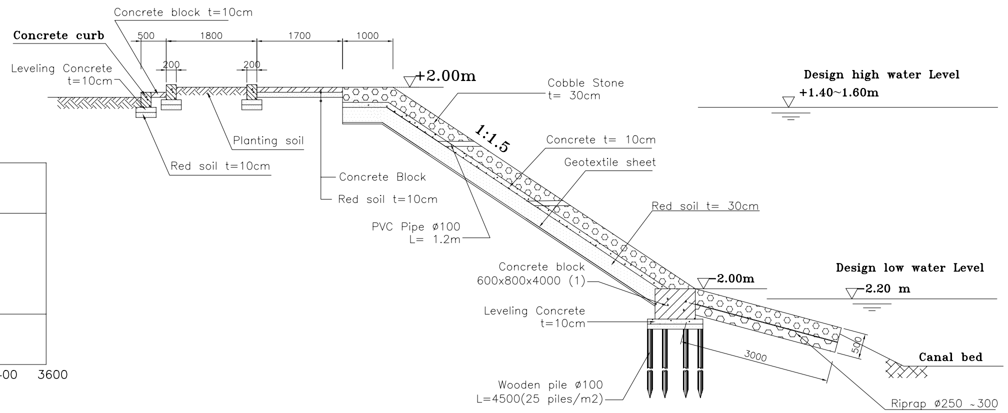
(Scale 1/150)

LONGTUDINAL PROFILE OF PROPOSED DIKE

Scale Horizontal: 1/30,000

Vertical: 1/75





Note:

1. Temporary dike should be constructed along the ring road in phase 1 project
2. Permanent dike along Lo Gom and Ngang No.3 canals should be constructed simultaneously with canal improvement works in phase 2 project

FIG. 4.2(3/3) PROPOSED DIKE CONSTRUCTION (BEN ME COC(2) AREA)

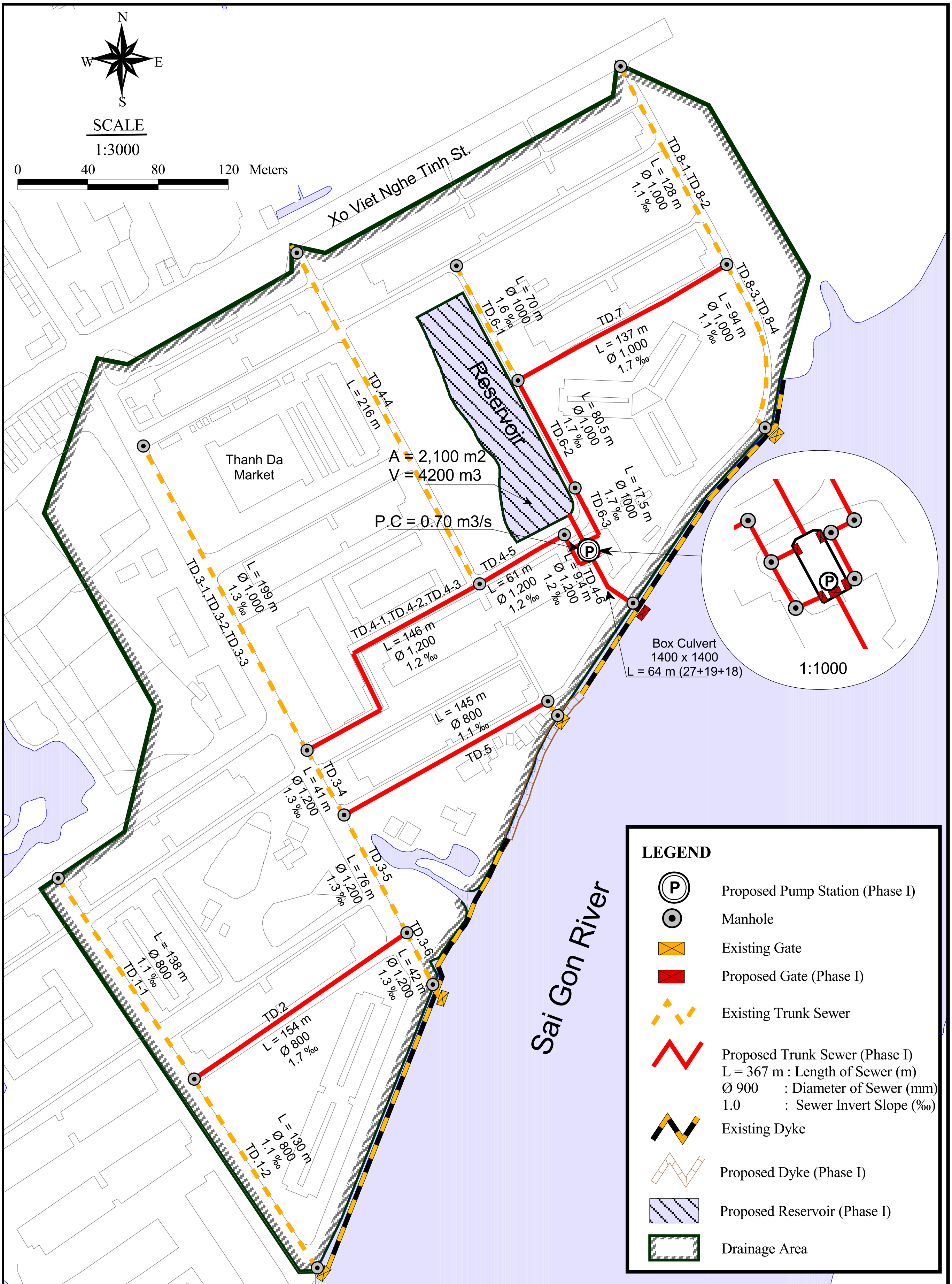


FIG .4.3 (1/3) PROPOSED DRAINAGE SYSTEM (THANH DA AREA)

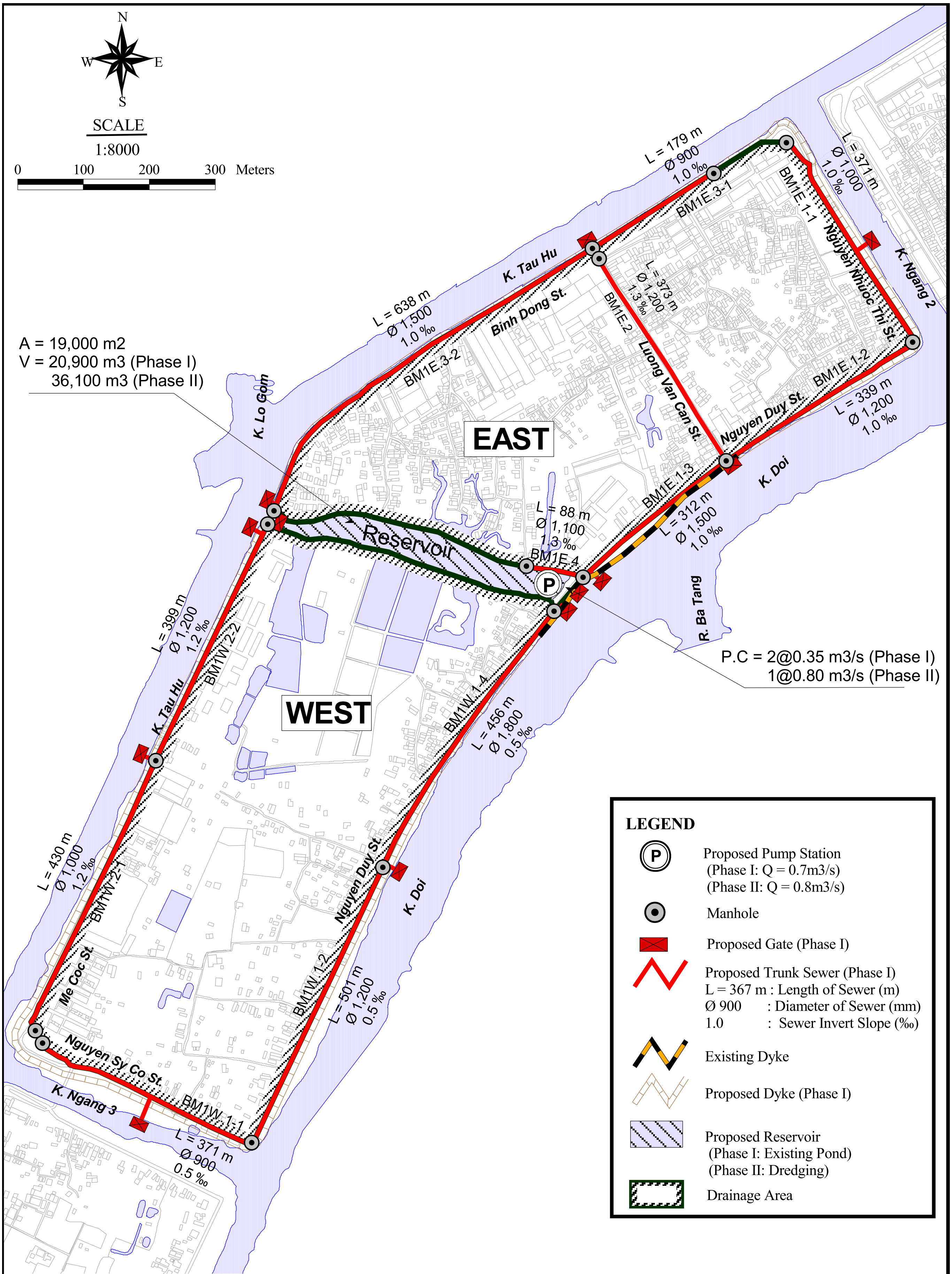


FIG. 4.3 (2/3) PROPOSED DRAINAGE SYSTEM (BEN ME COC 1 AREA)

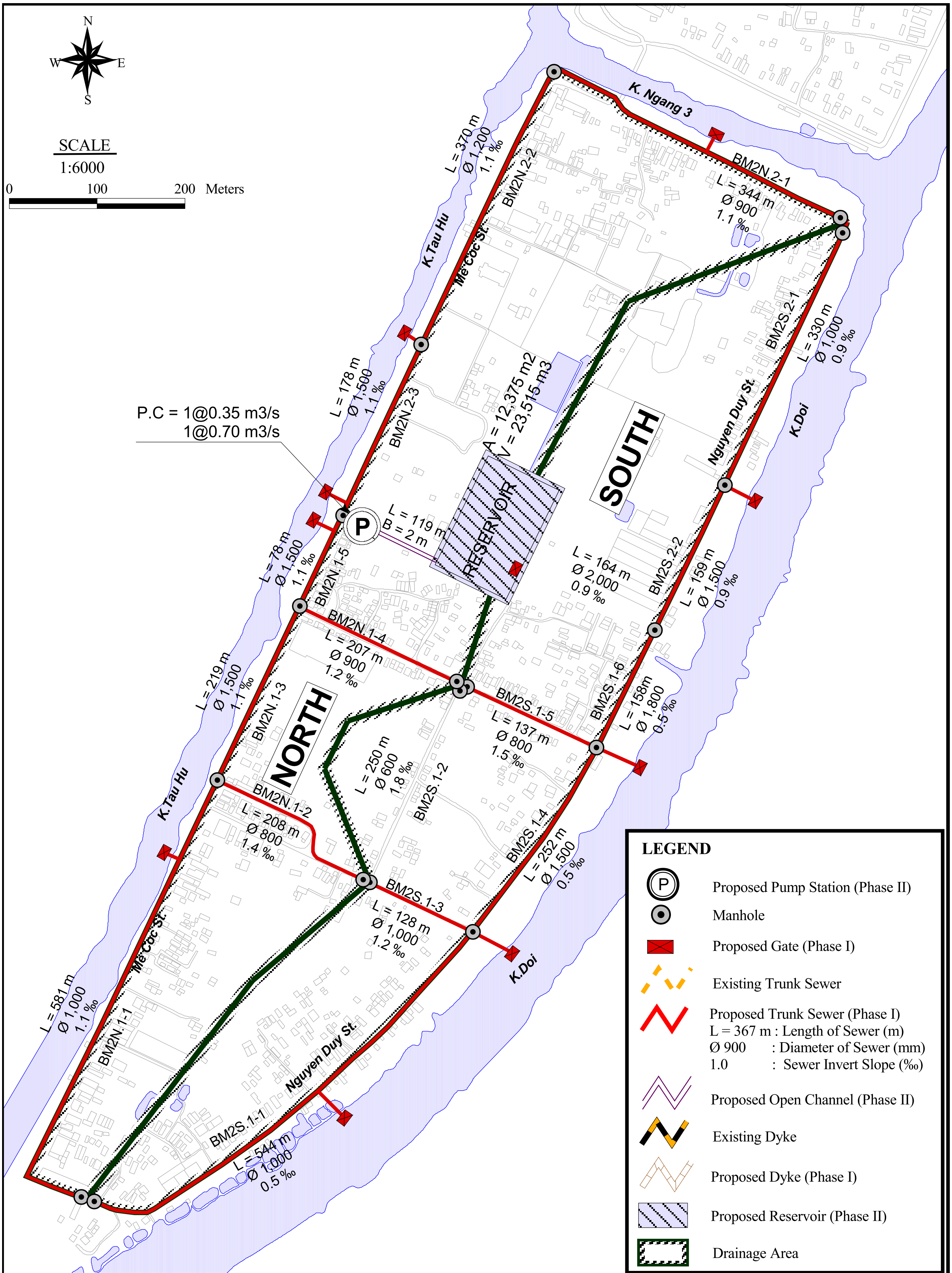


FIG. 4.3 (3/3) PROPOSED DRAINAGE SYSTEM (BEN ME COC 2 AREA)

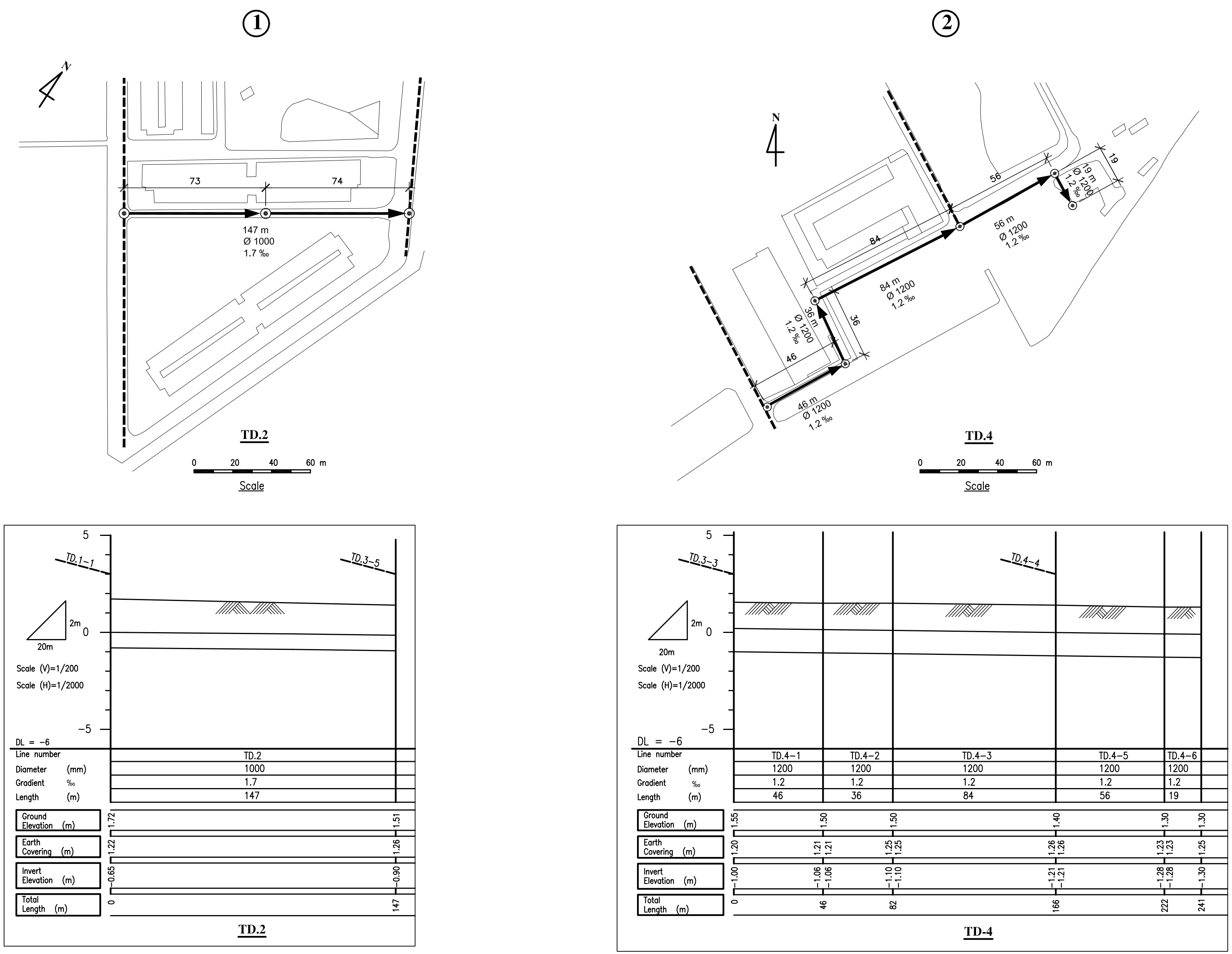


FIG. 4.4 PROPOSED SEWER LINE CONSTRUCTION IN THANH DA AREA

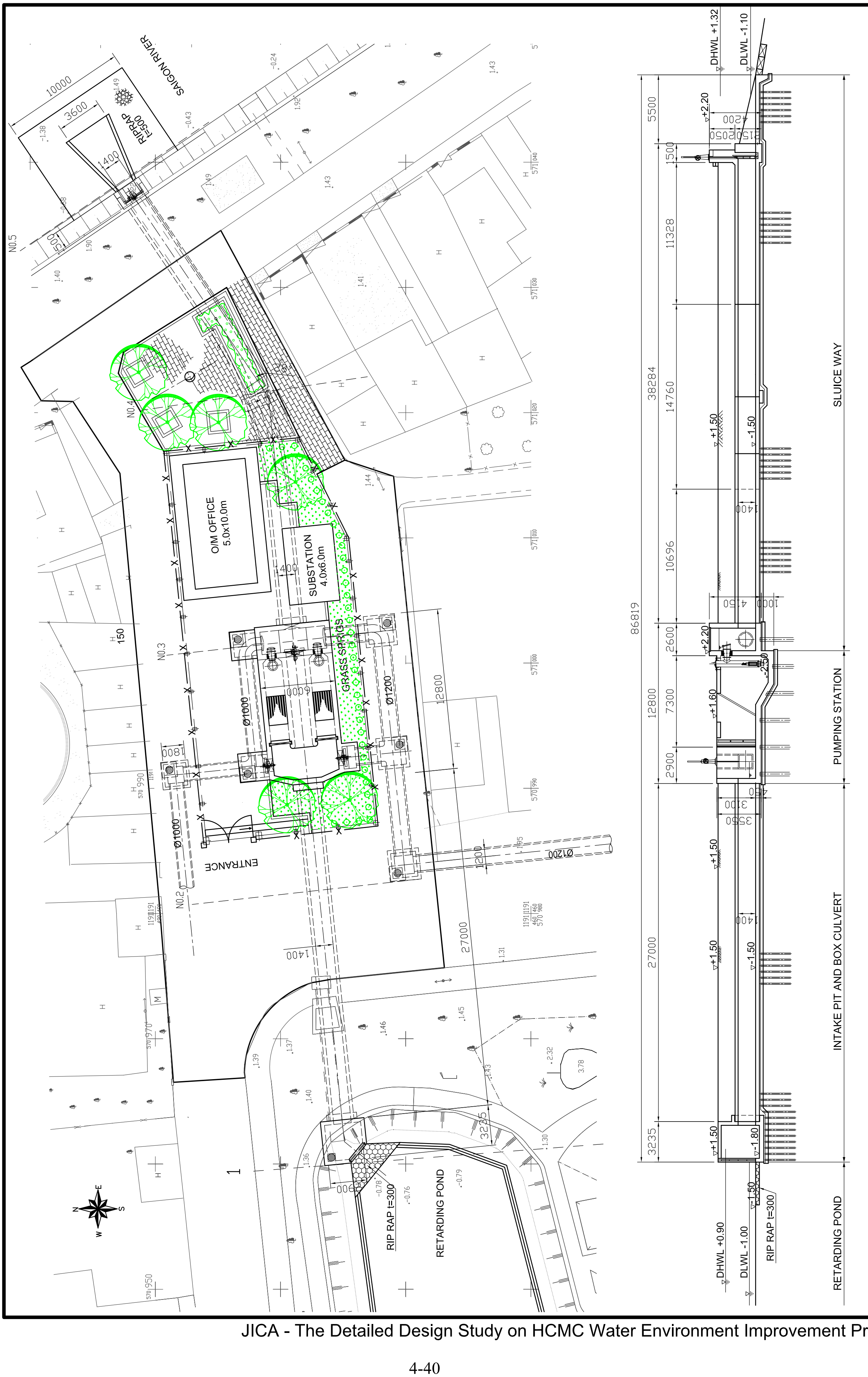


FIG. 4.5 GENERAL LAYOUT OF THANH DA PUMPING STATION

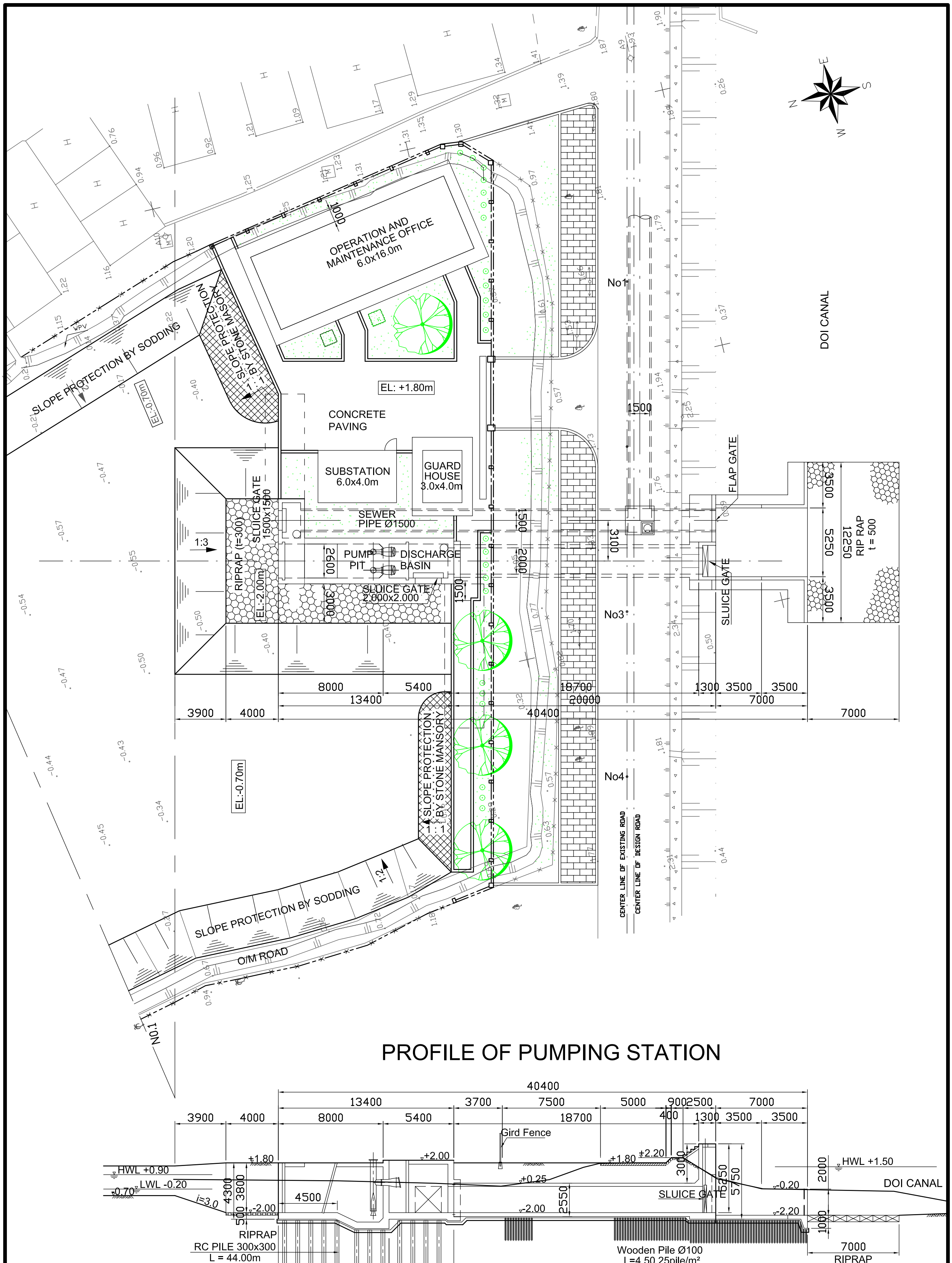
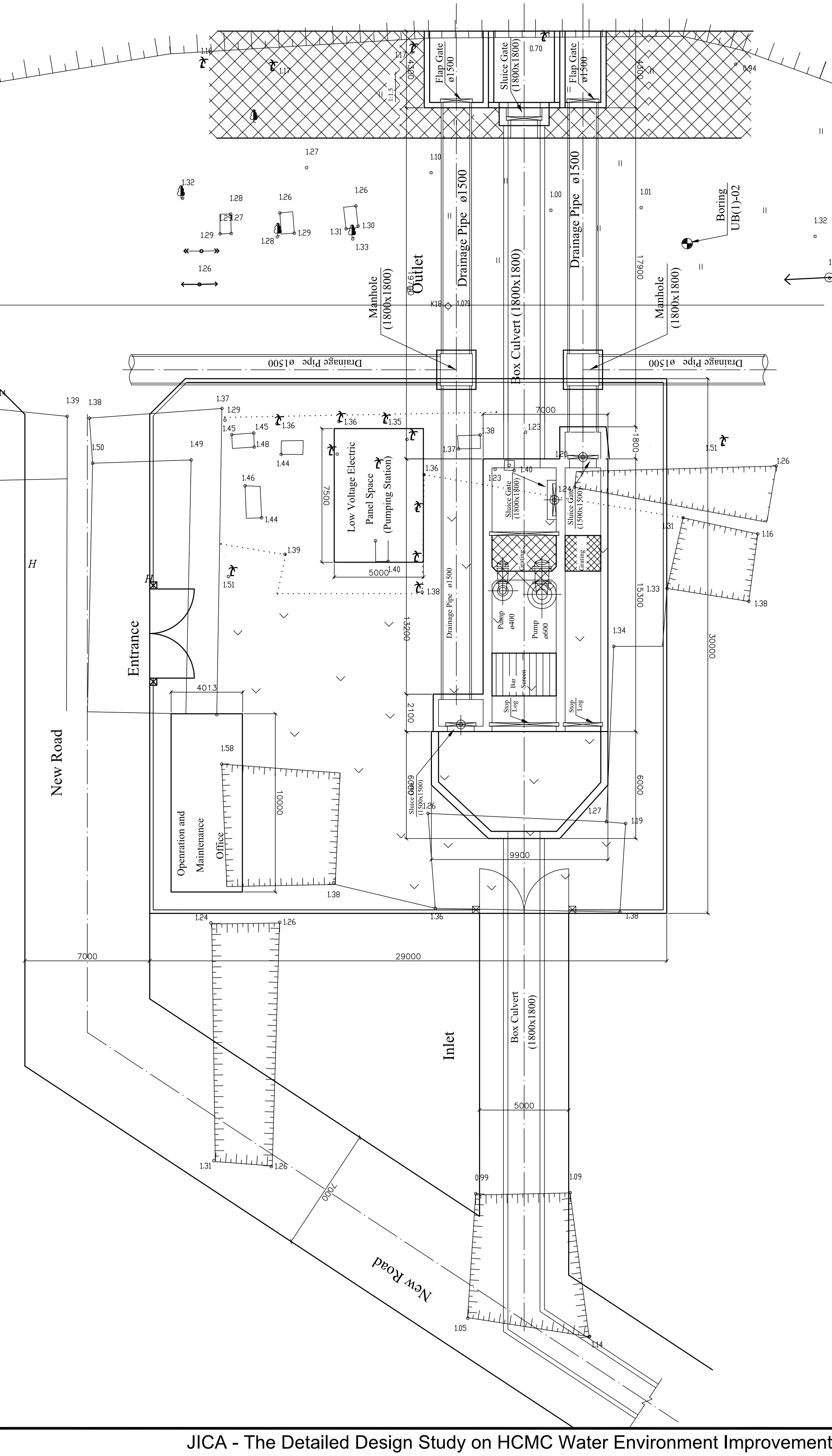


FIG. 4.6 GENERAL LAYOUT OF BEN ME COC (1) PUMPING STATION



Scale 1:300

FIG. 4.7 LAYOUT OF PROPOSED BEN ME COC (2) PUMPING STATION

SCALE 1:150

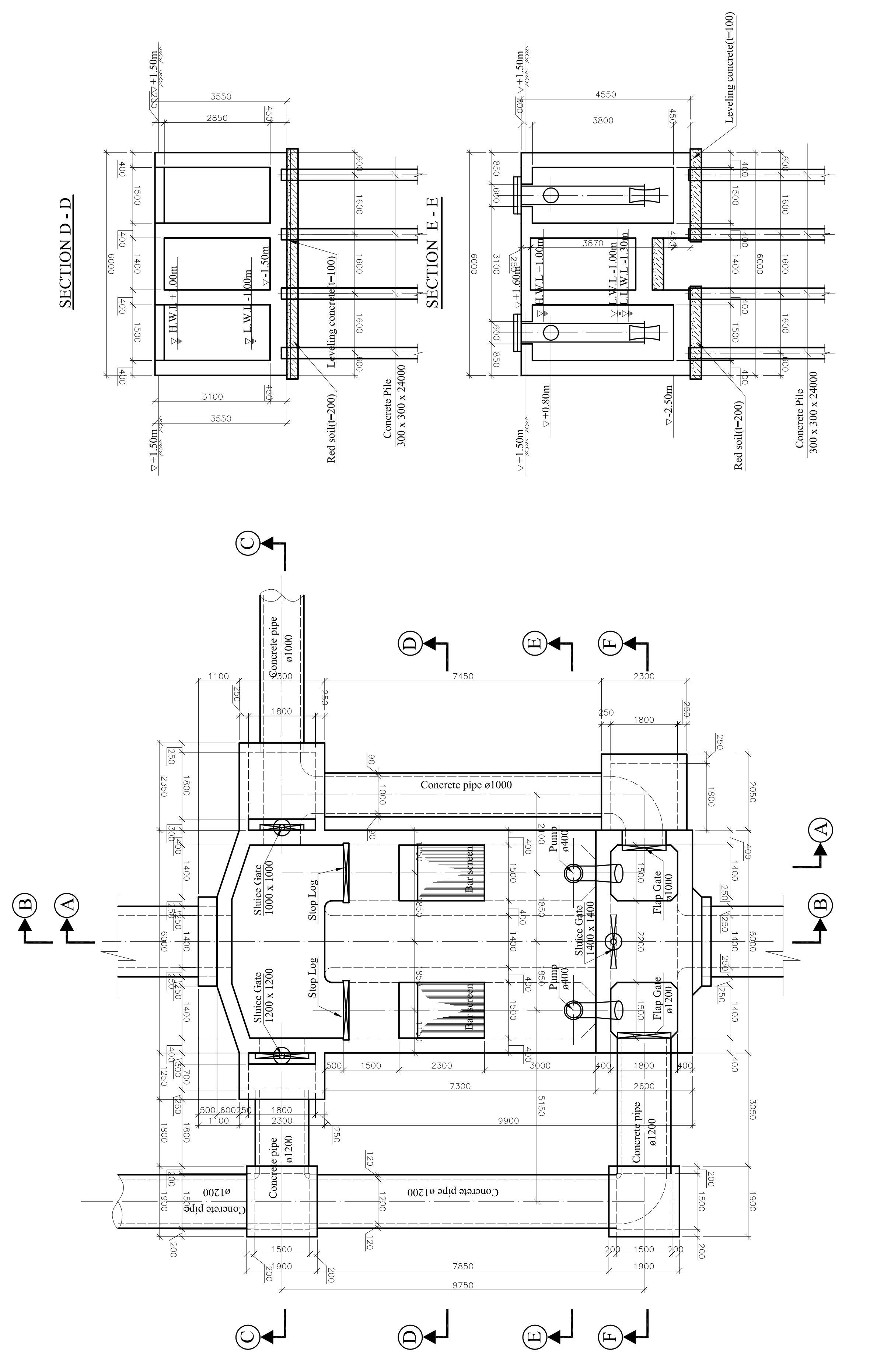


FIG. 4.8(1/3) STRUCTURAL DESIGN OF PROPOSED THANH DA PUMPING STATION

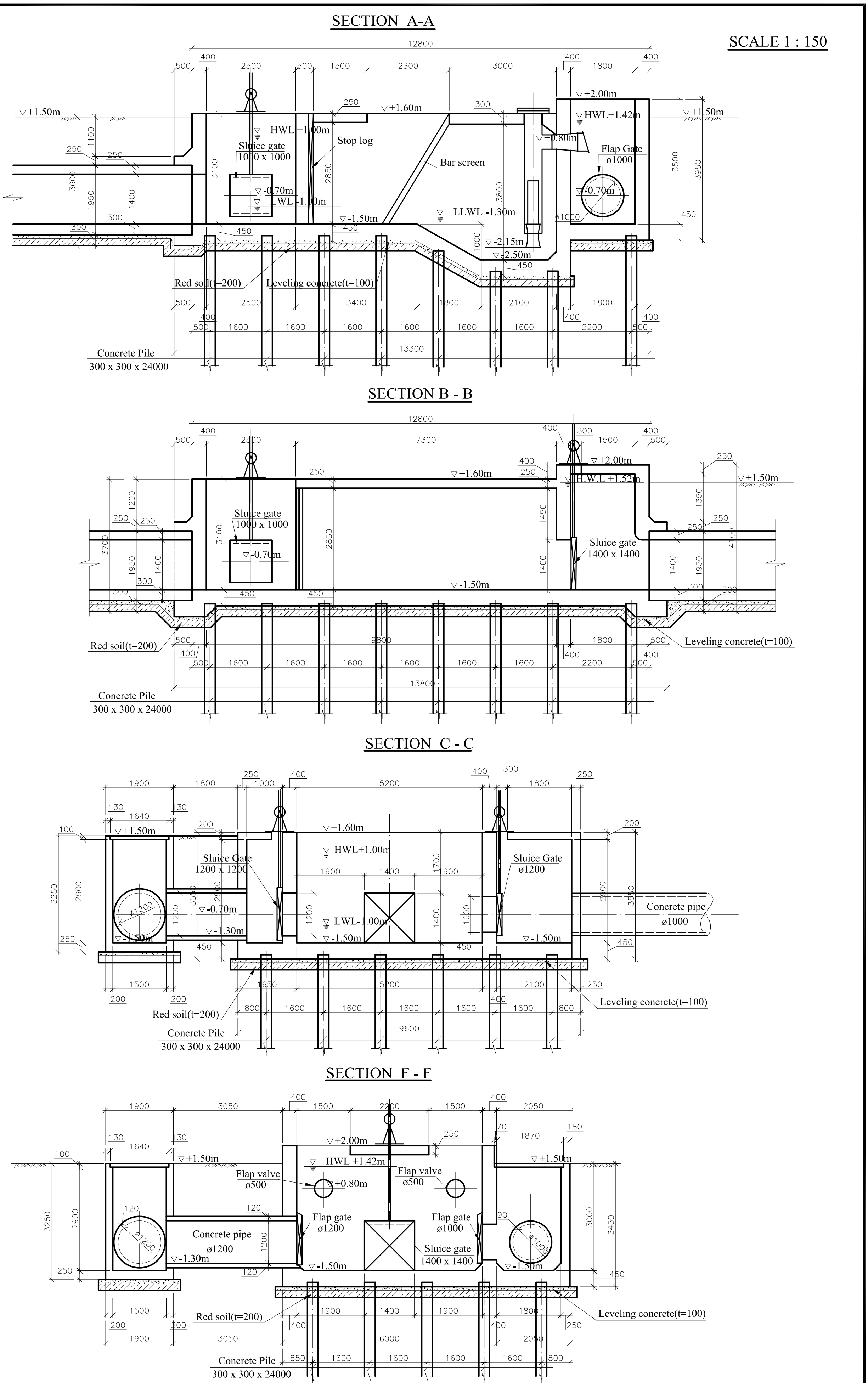


FIG. 4.8(2/3) STRUCTURAL DESIGN OF PROPOSED THANH DA PUMPING STATION

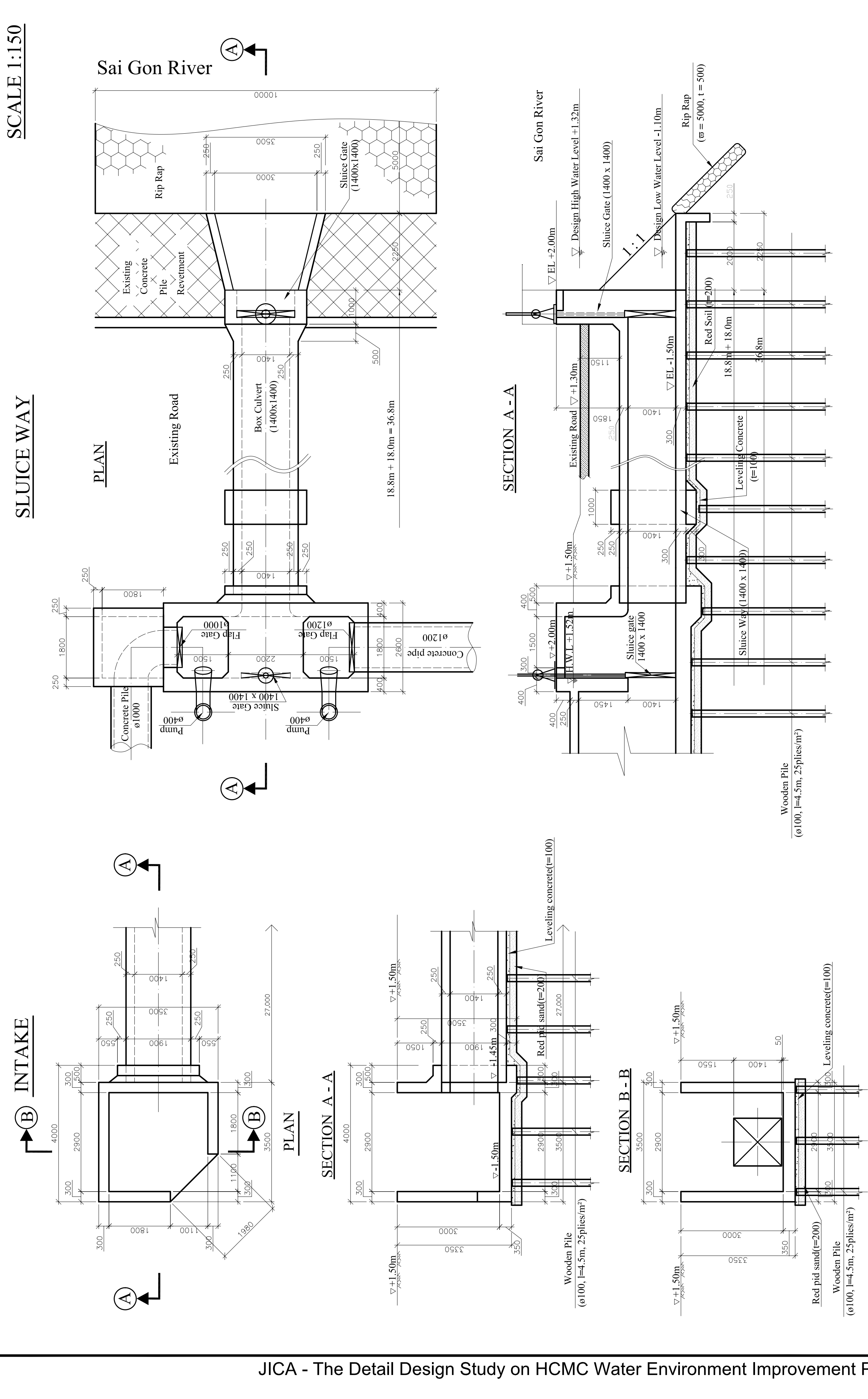


FIG. 4.8(3/3) STRUCTURAL DESIGN OF PROPOSED THANH DA PUMPING STATION

SCALE 1 : 250

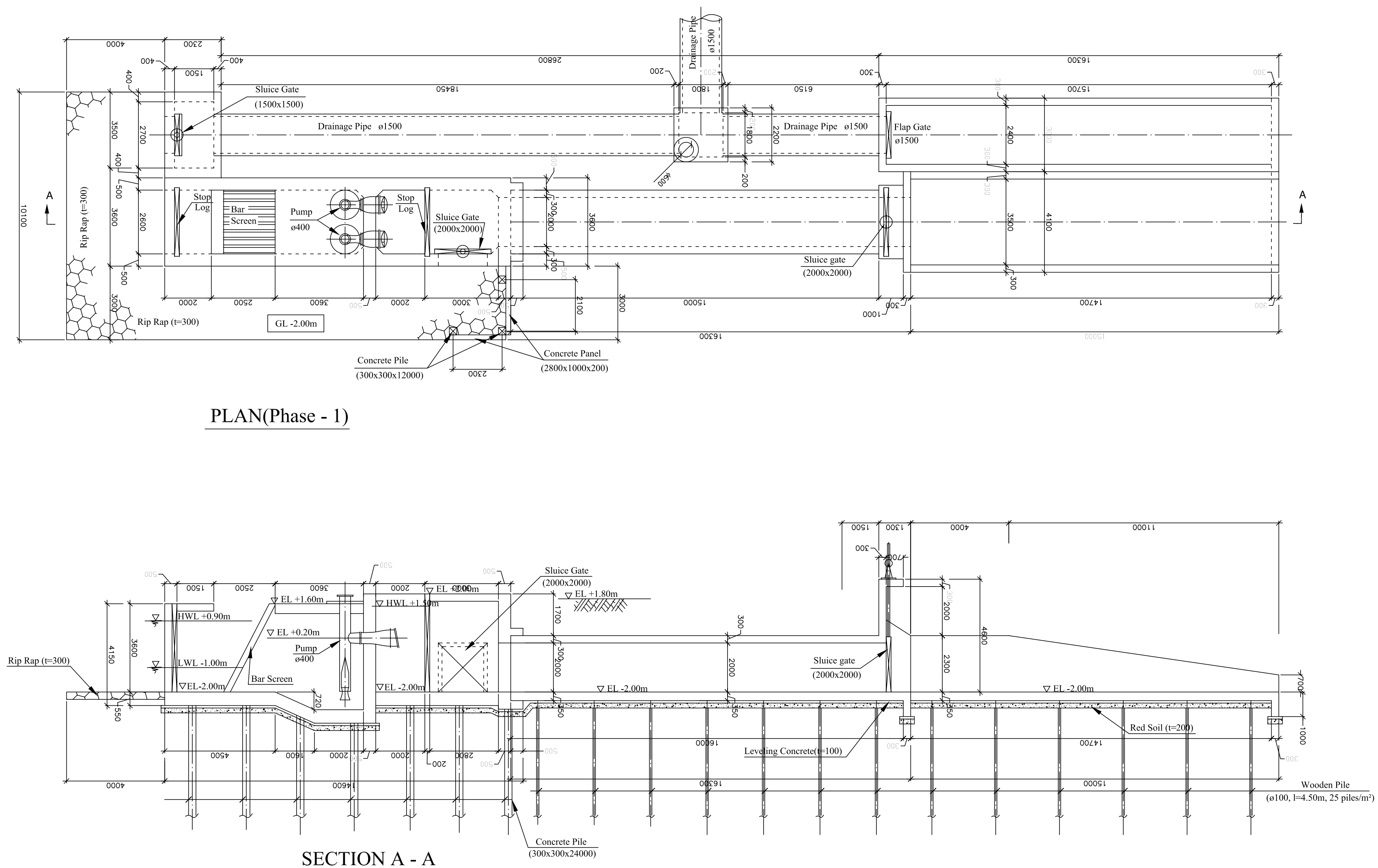
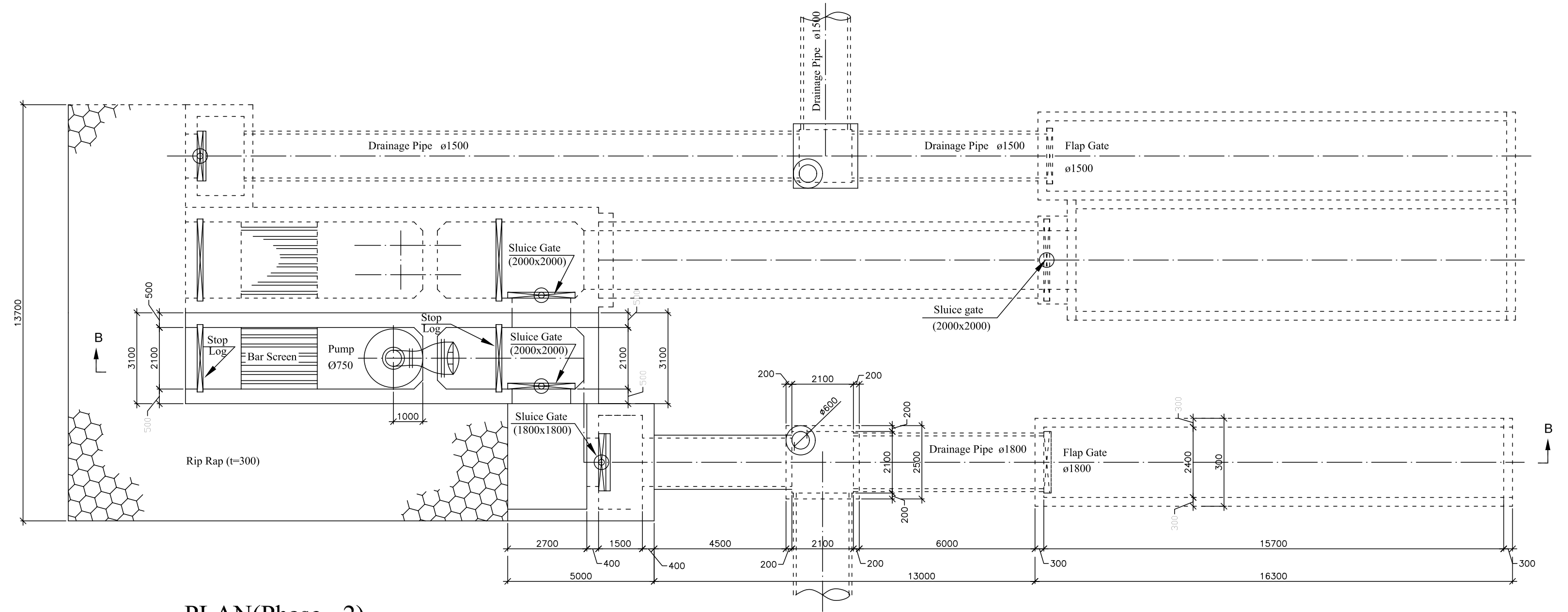
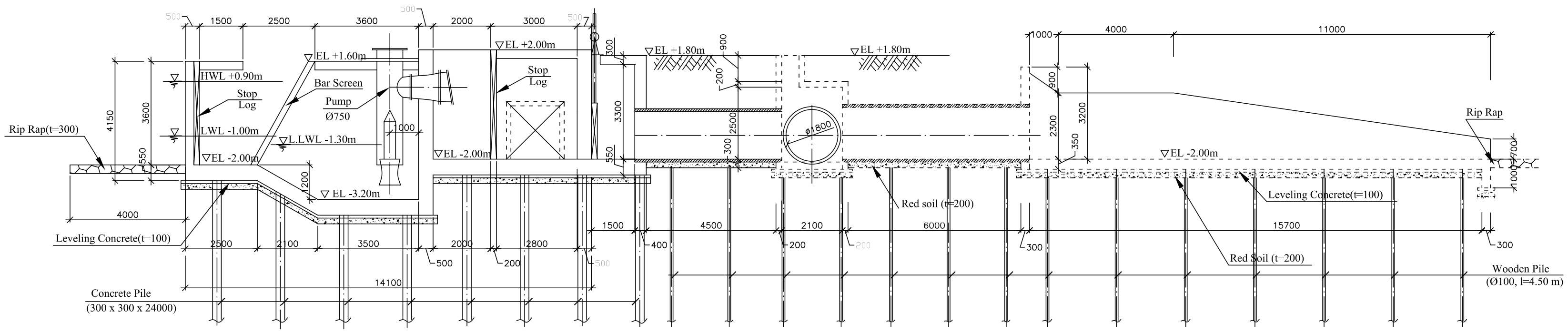


FIG. 4.9(1/2) STRUCTURAL DESIGN OF PROPOSED BEN ME COC (1) PUMPING STATION (Phase-1)

SCALE 1:250



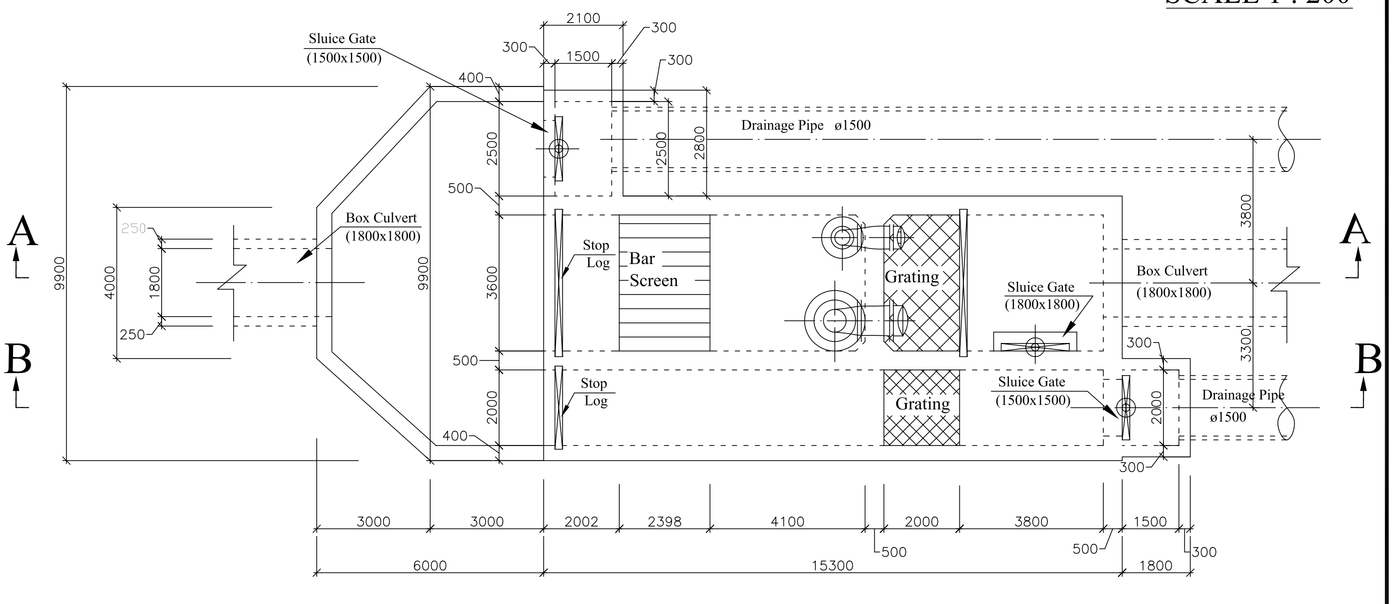
PLAN(Phase - 2)



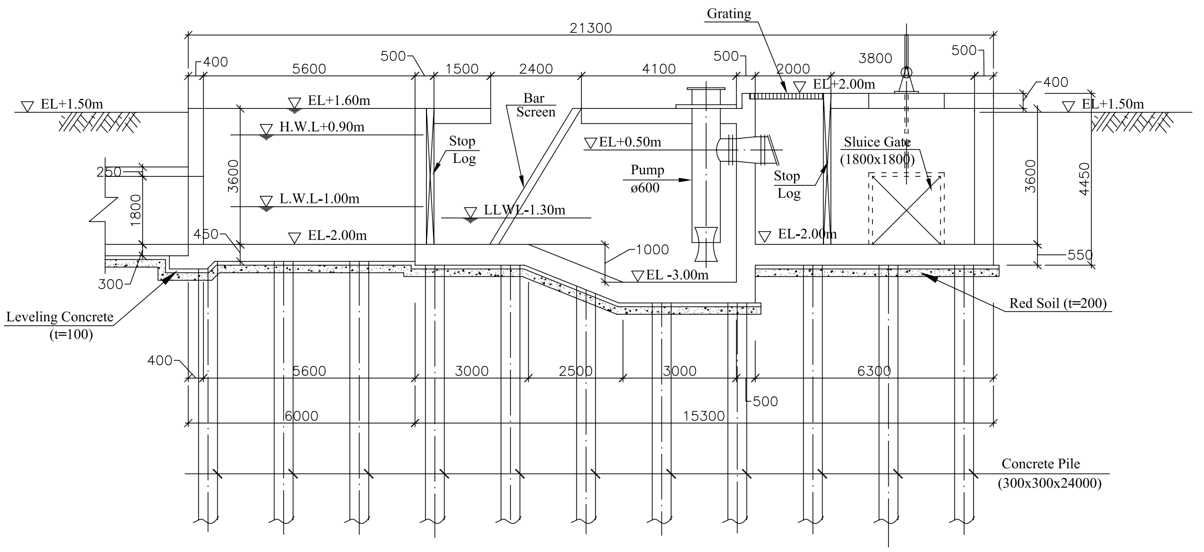
SECTION B - B

FIG. 4.9(2/2) STRUCTURAL DESIGN OF PROPOSED BEN ME COC (1) PUMPING STATION (Phase-2)

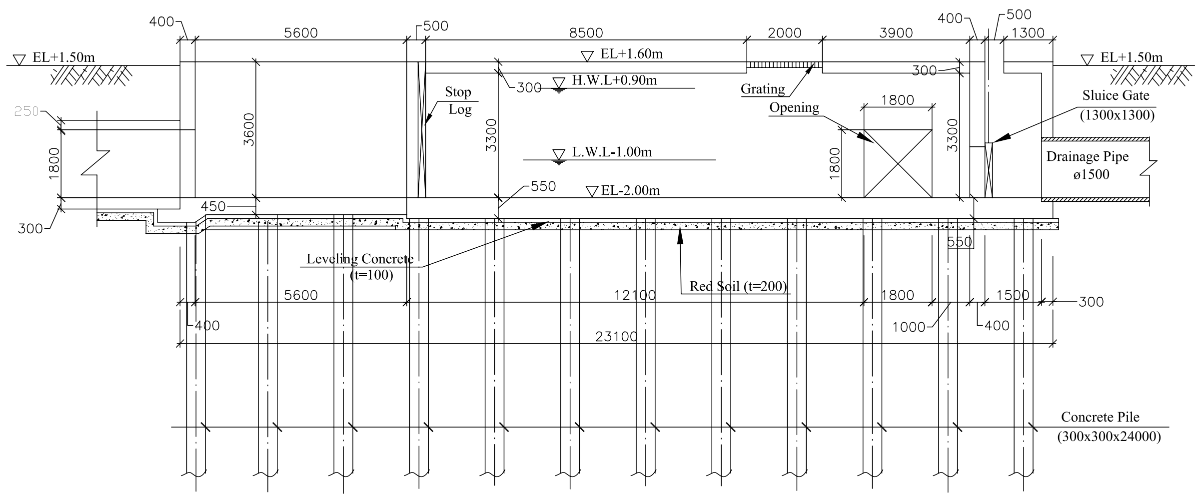
SCALE 1 : 200



PLAN



SECTION A - A



SECTION B - B

FIG. 4.10(1/2) STRUCTURAL DESIGN OF PROPOSED BEN ME COC (2) PUMPING STATION

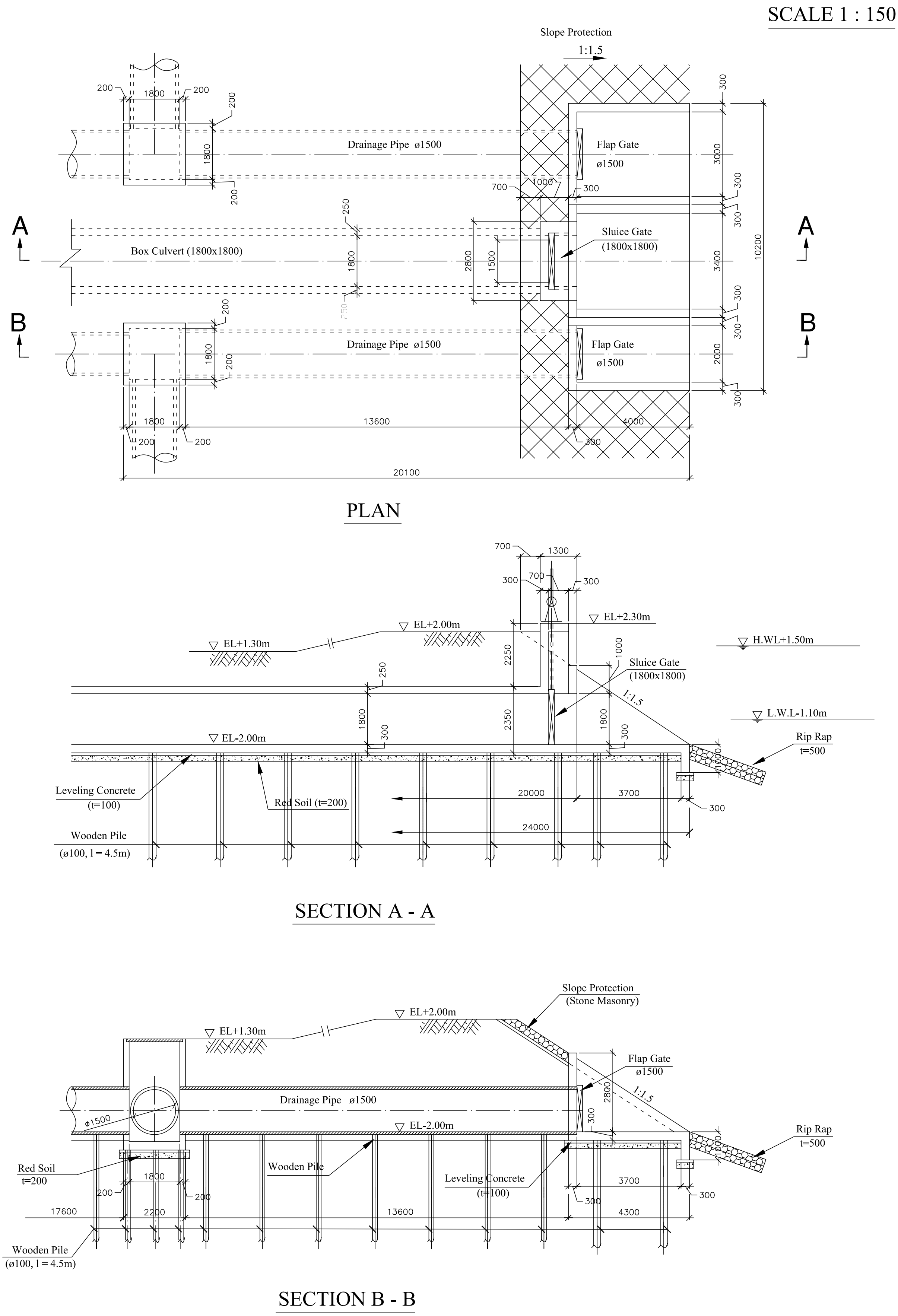
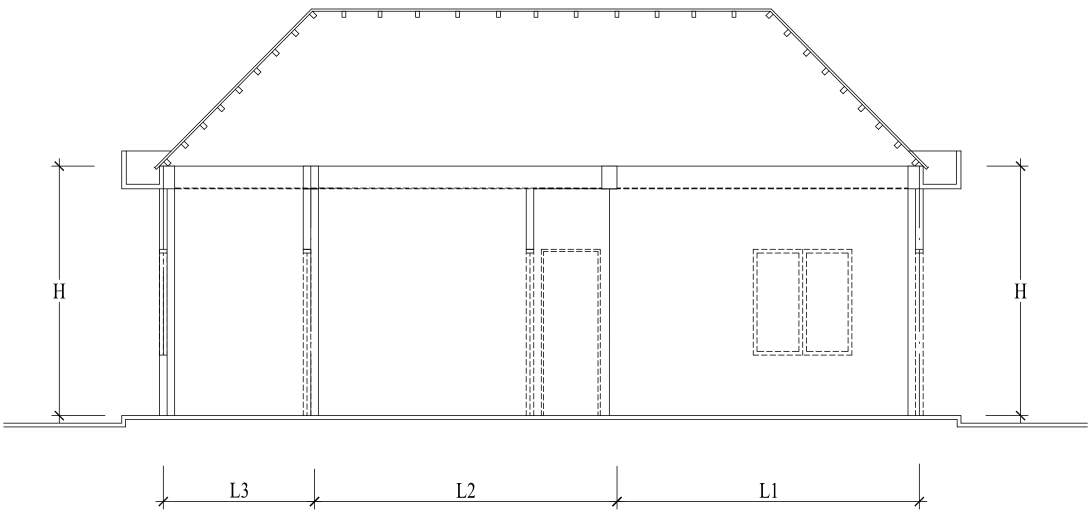
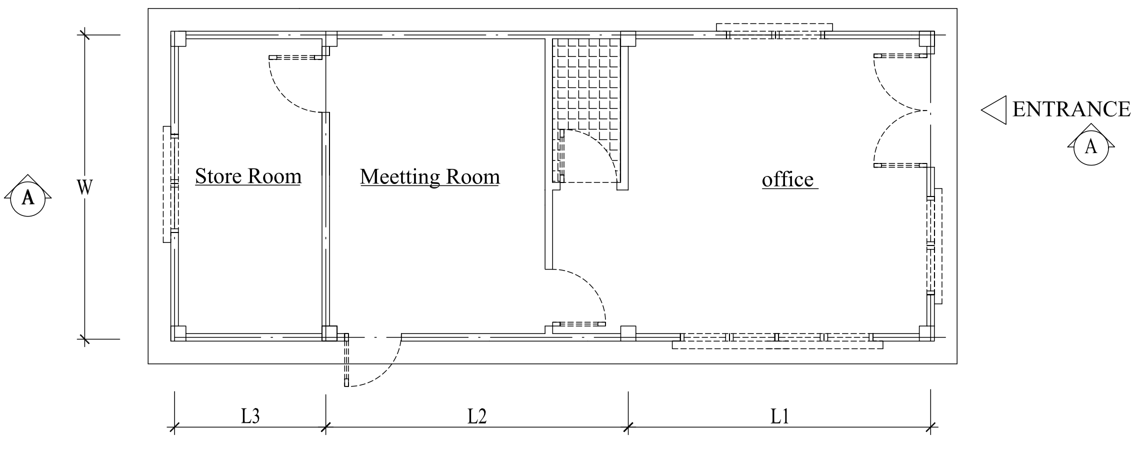


FIG. 4.10(2/2) STRUCTURAL DESIGN OF PROPOSED BEN ME COC (2) PUMPING STATION



SECTION A-A



O&M OFFICE PLAN

Unit : mm

	Me Coc 1	Me Coc 2	Thanh Da
L1	4000	4000	4000
L2	8000	4000	4000
L3	4000	2000	2000
W	5000	4000	4000
H	3500	3500	3500

FIG. 4.11 TYPICAL DESIGN OF OPERATION & MAINTENANCE OFFICE

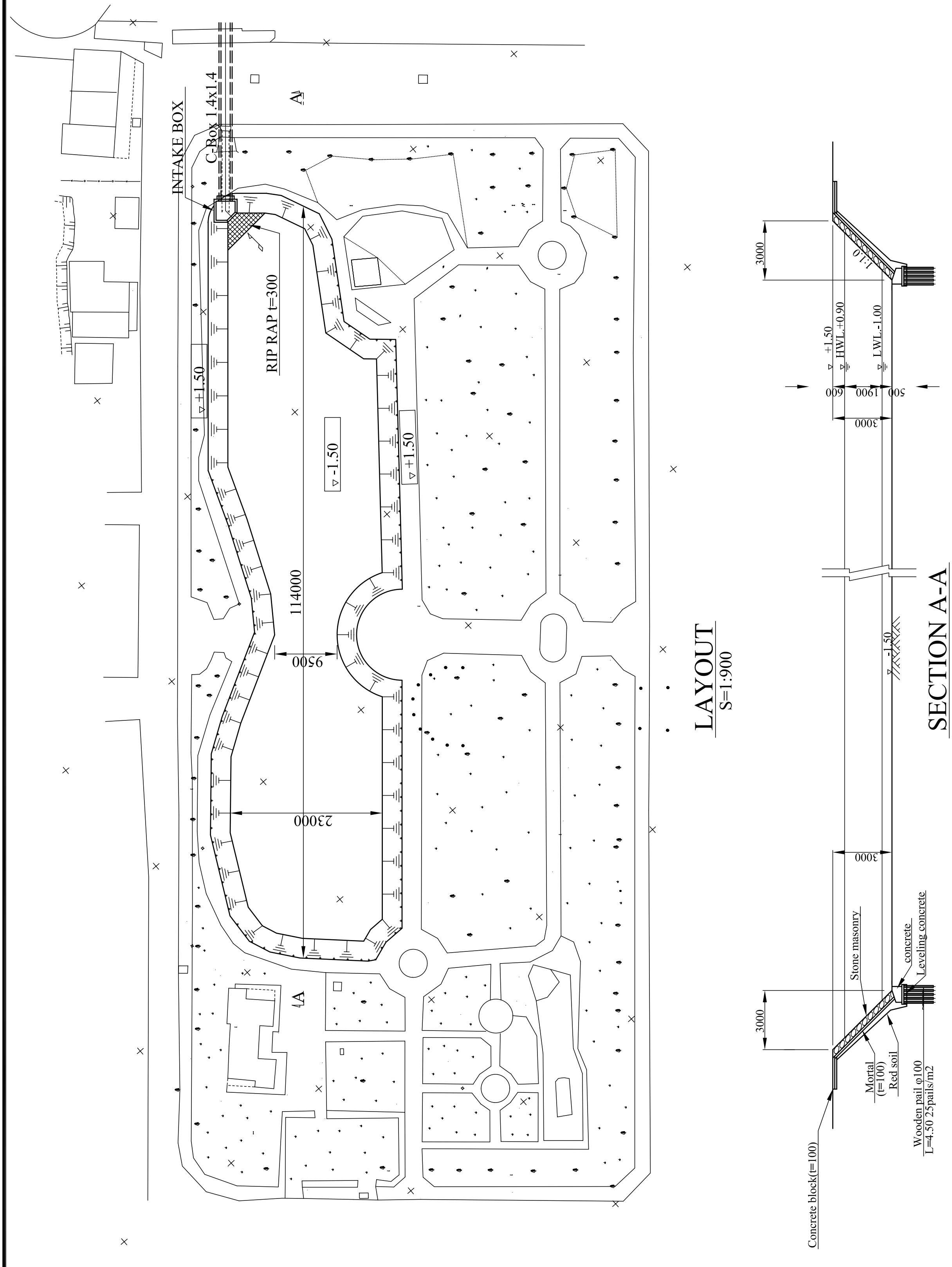
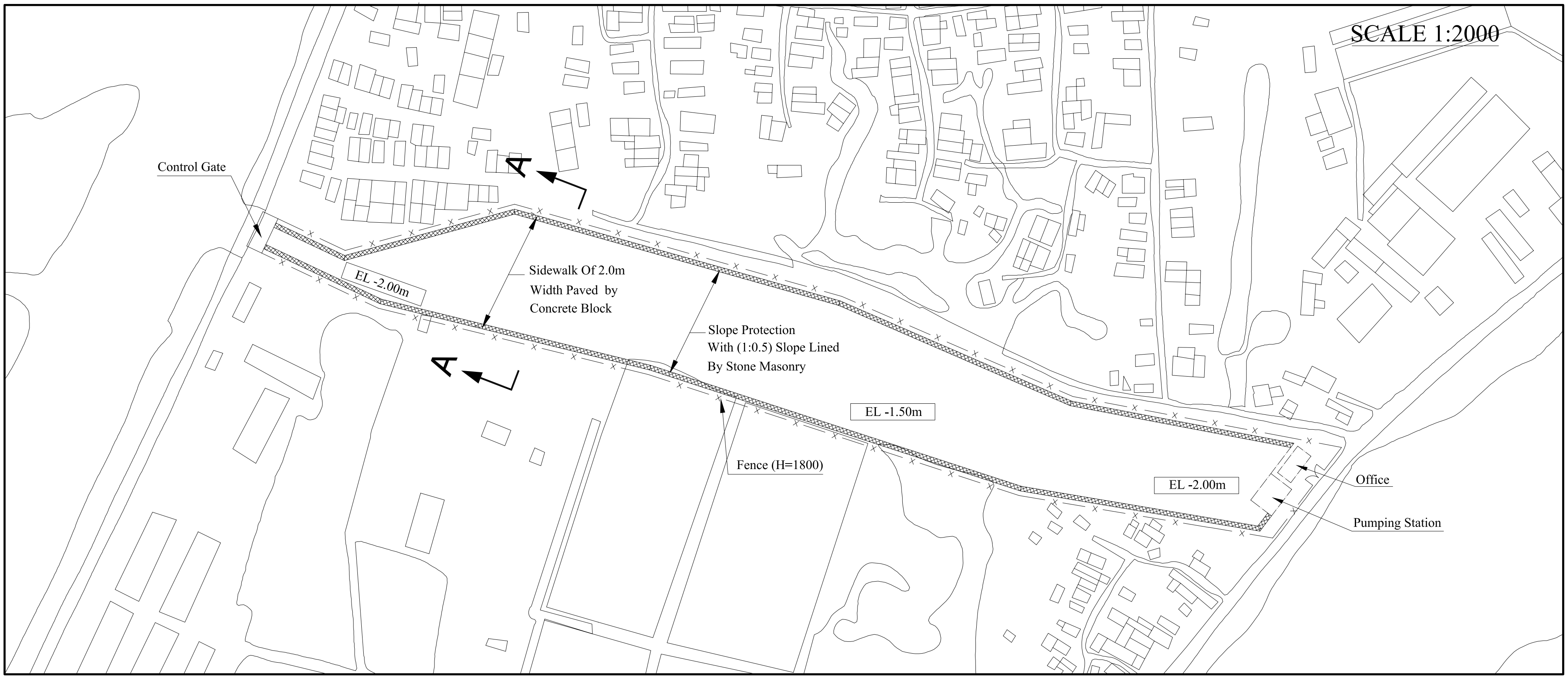
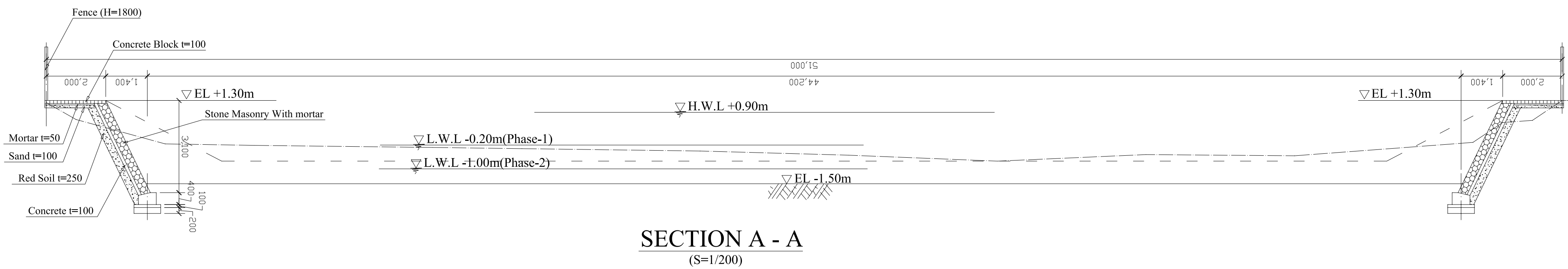


FIG. 4.12 PROPOSED RECONSTRUCTION OF EXISTING POND IN THANH DA PARK





SECTION A - A
(S=1/200)

FIG. 4.13 LAYOUT OF PROPOSED RETARDING POND OF BEN ME COC (1) PUMPING STATION

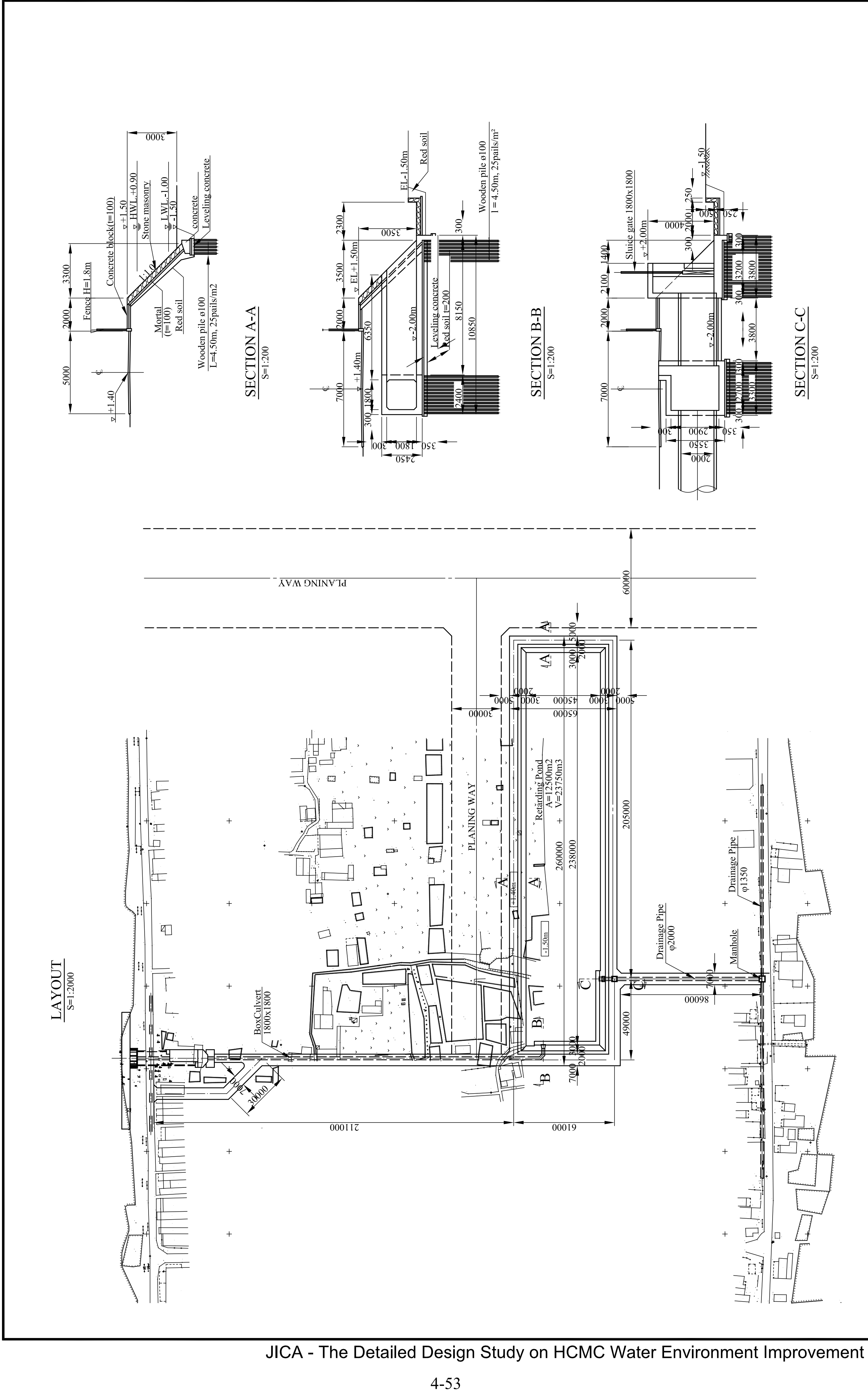
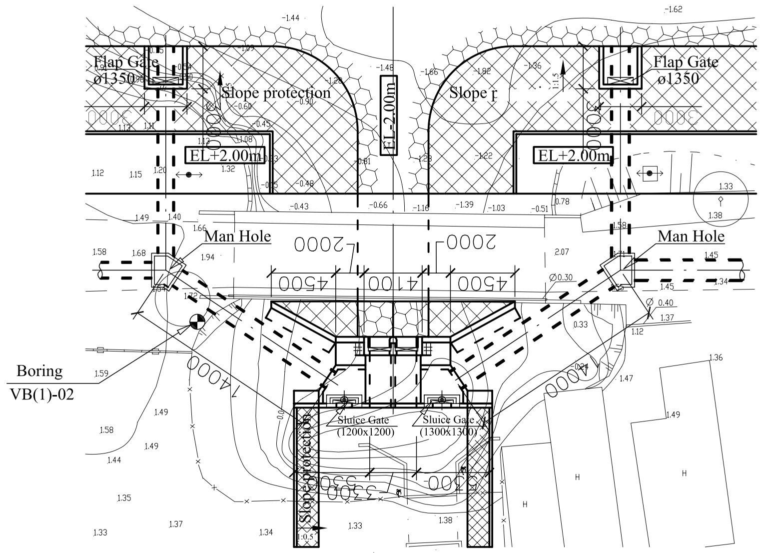
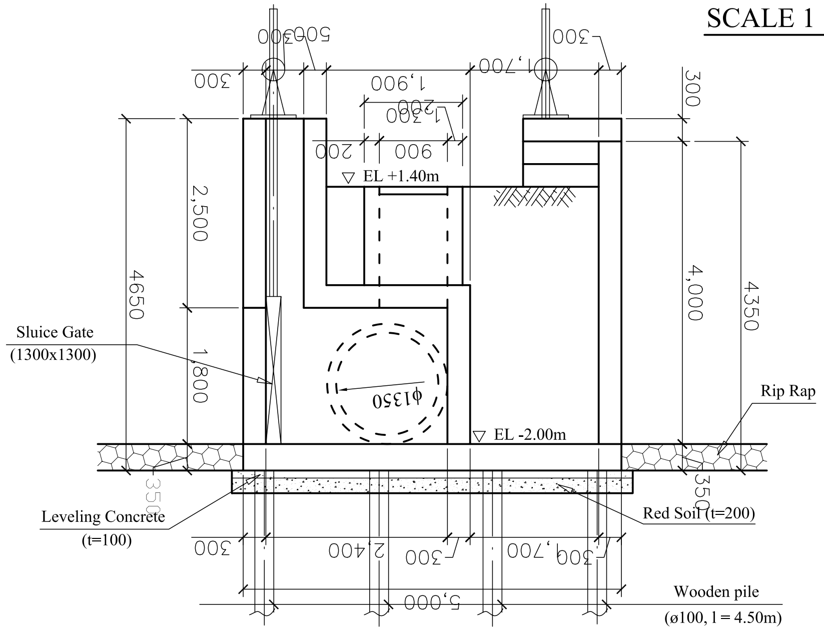


FIG. 4.14 LAYOUT AND STRUCTURAL DESIGN OF PROPOSED RETARDING POND OF BEN ME COC (2)

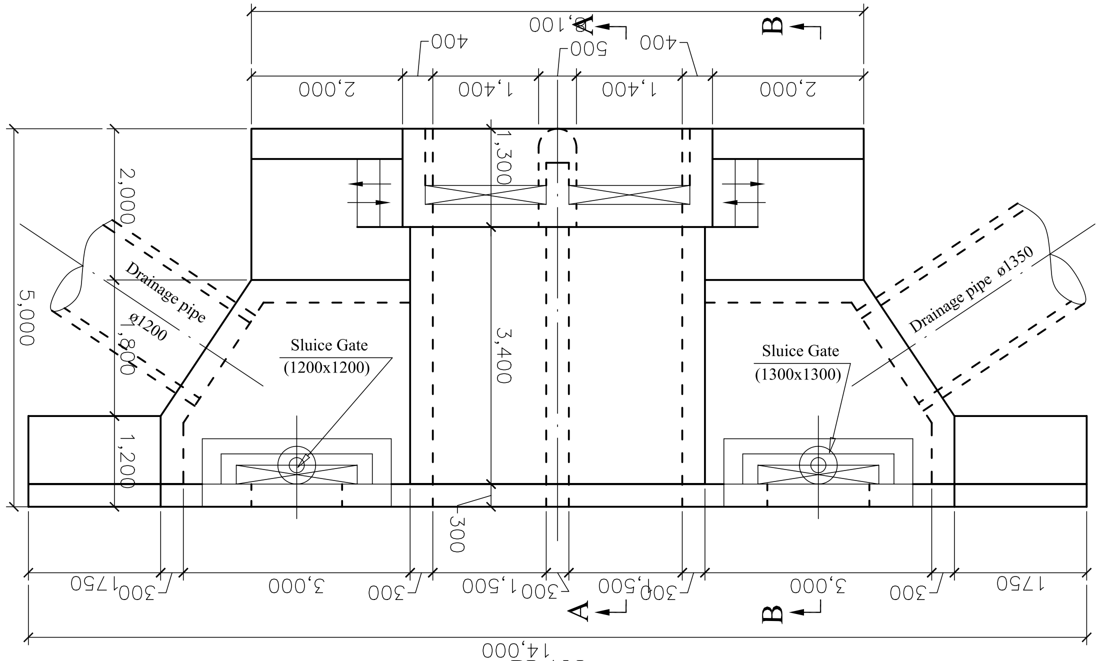
SCALE 1 : 100



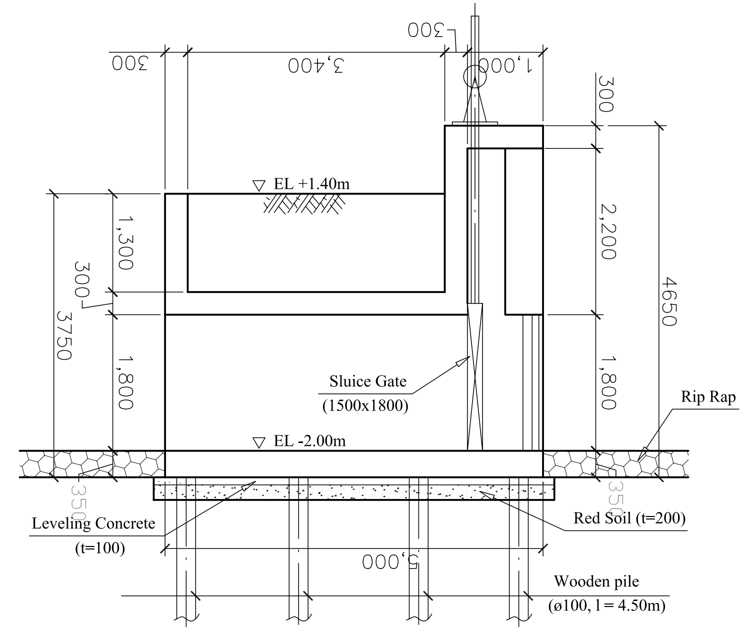
LAYOUT



SECTION B - B



PLAN

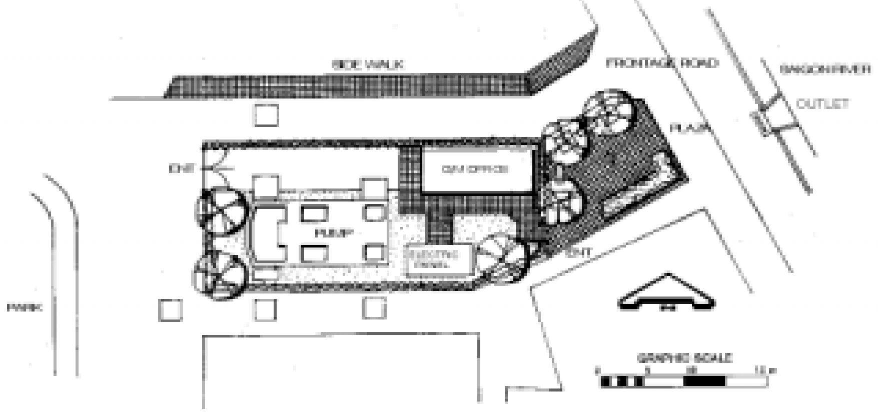


SECTION A - A

FIG. 4.15 LAYOUT AND STRUCTURAL DESIGN OF PROPOSED CONTROL GATE IN BEN ME COC (1)

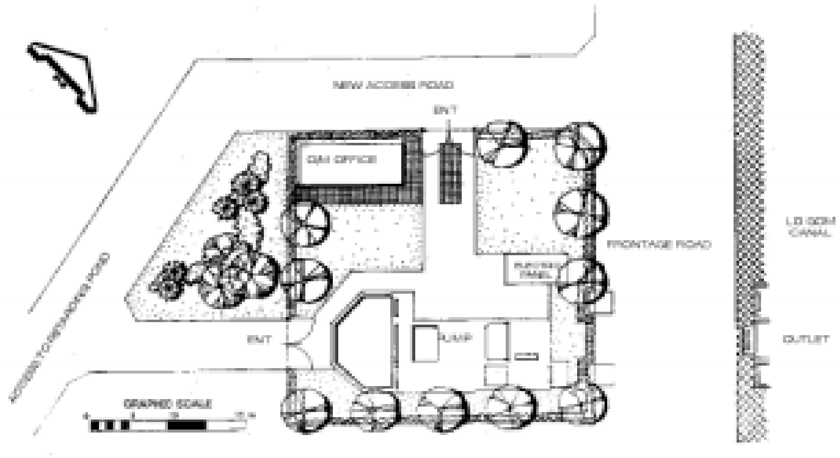
PROPOSED LANDSCAPE SCHEMATIC LAYOUT PLAN FOR DRAINAGE PUMPING STATION SITES

THANH DA PUMPING STATION



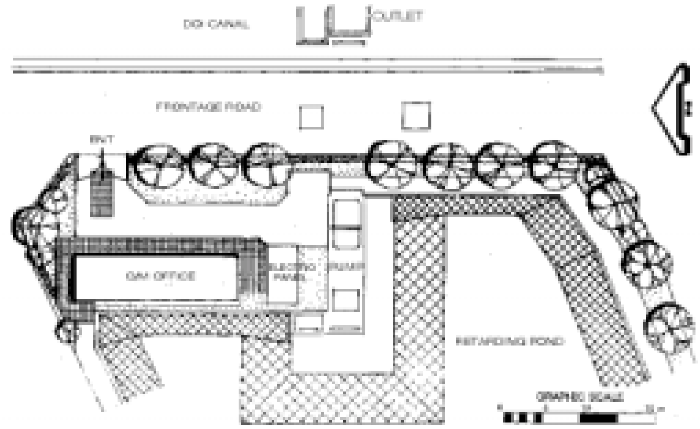
Facility surrounding area shall have a safety and functional buffer spaces for access alley and small plaza for community use.

BEN ME COC - 2 PUMPING STATION



Facility adjacent space born along new access road shall be furnished plantings with gardening type in harmony with surrounding existing landscape.

BEN ME COC -1 PUMPING STATION



Service access space for maintenance shall be considered enough turning allowance for vehicle moving within limited space.

LANDSCAPE DESIGN CRITERIA

Functional flow of access and activity for operation / maintenance staffs and vehicles shall be kept in site layout plan.

Main access for motor vehicle shall be minimum 4.0m in width and concrete paving finish, and colored concrete block paving with 2.0m in width shall be installed along with the operation / maintenance office for aesthetic consideration.

All facility sites shall be enclosed by fence with 2.4 m in height and major gate door shall be minimum 4.0m in width of enough space for motor vehicle goes in.

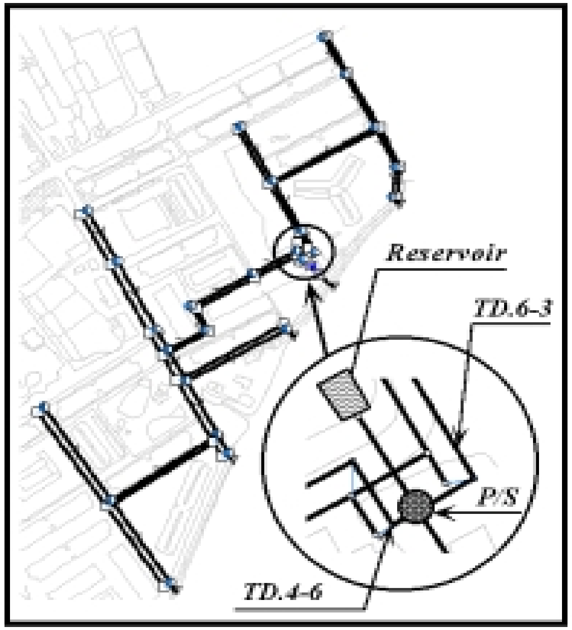
Plantings shall be introduced for establishing aesthetic and safety environmental condition of the facility site. Medium trees as major objectives shall be introduced for provision of canopy with seasonal flowering to the vicinity peoples.

Some small flowering shrubs shall be also provided for an accent of the planting layout scheme.

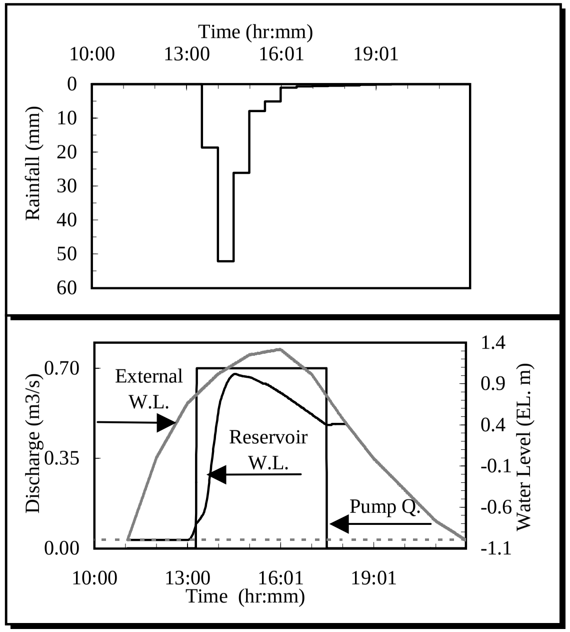
Along the enclosure fence especially it faces either to the frontage road or the access road, species of flowering shrub, vine and creeper shall be introduced as a hedge planting.

Facility spaces in which without any paving provision shall be furnished with turf grass or some proper ground cover plants, so that all the facility space will be covered in condition of clean and amicable environment accordingly.

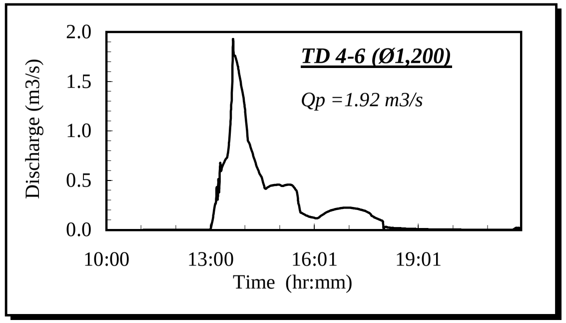
FIG. 4.16 LANDSCAPE PLAN FOR THE DRAINAGE PUMPING STATION SITES

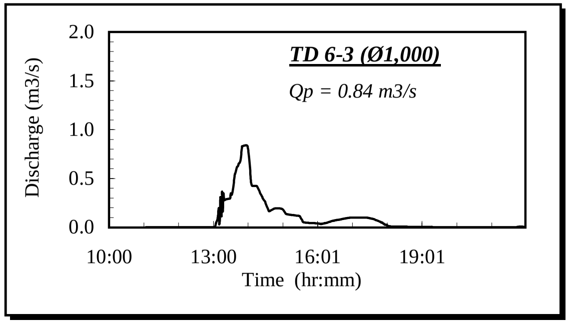


HYDRODYNAMIC MODEL NETWORK



RESERVOIR WATER LEVEL AND PUMP OPERATION

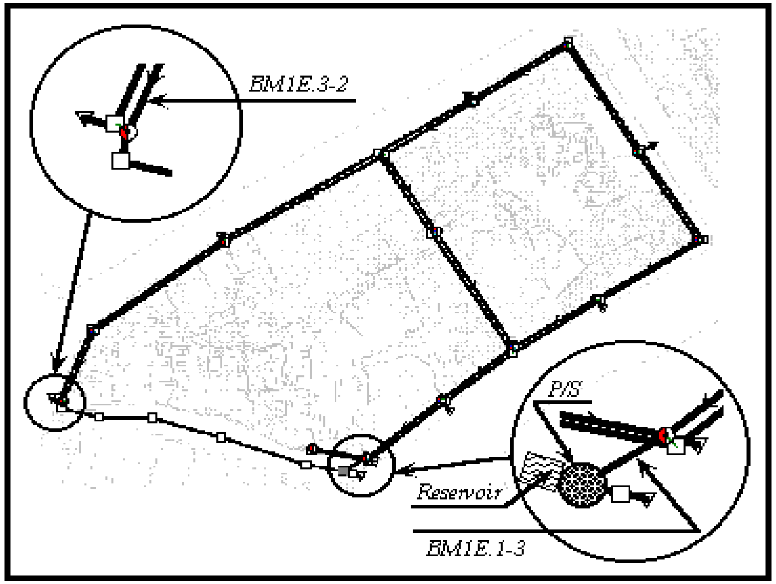




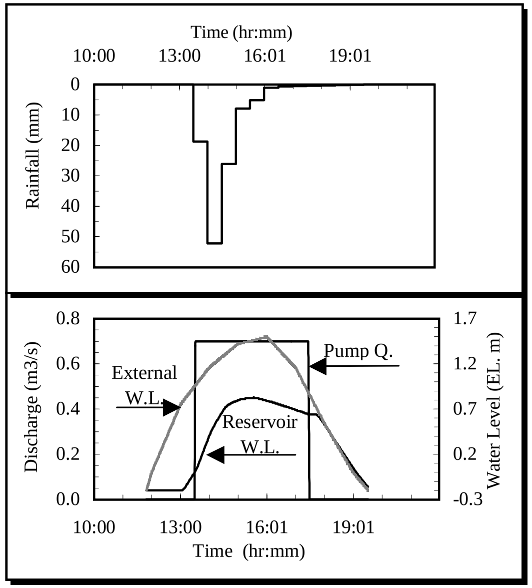
DISCHARGE HYDROGRAPHS TO RESERVOIR

CASE 1: THANH DA AREA (PHASE I)

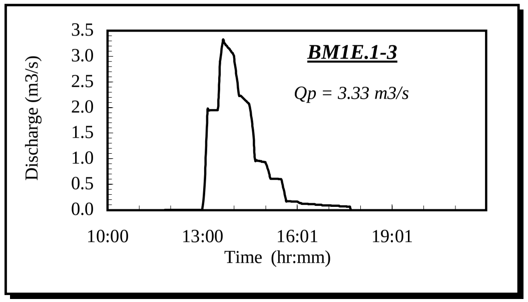
FIG. 4.17 (1/4) HYDRODYNAMIC SIMULATION RESULT FROM MOUSE

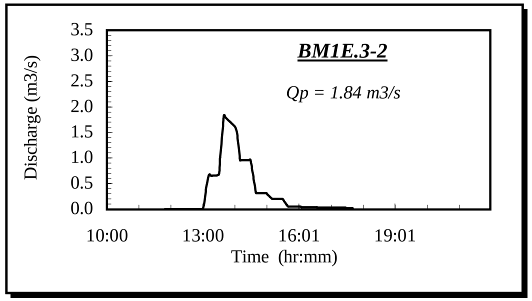


HYDRODYNAMIC MODEL NETWORK



RESERVOIR WATER LEVEL AND PUMP OPERATION

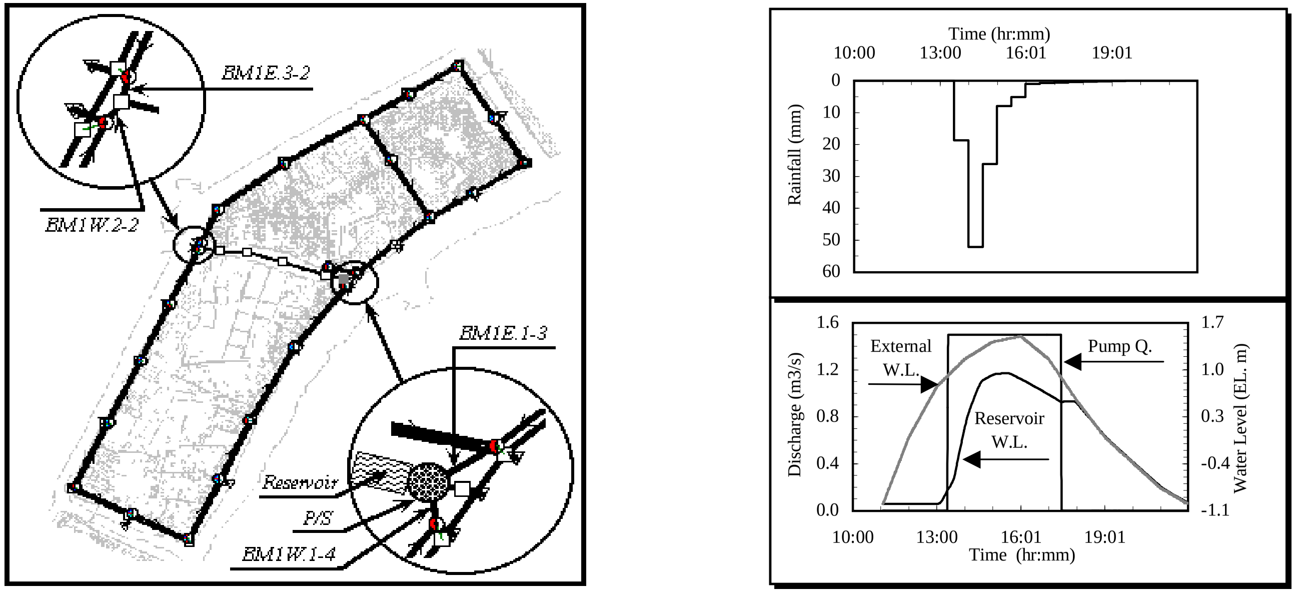




DISCHARGE HYDROGRAPHS TO RESERVOIR

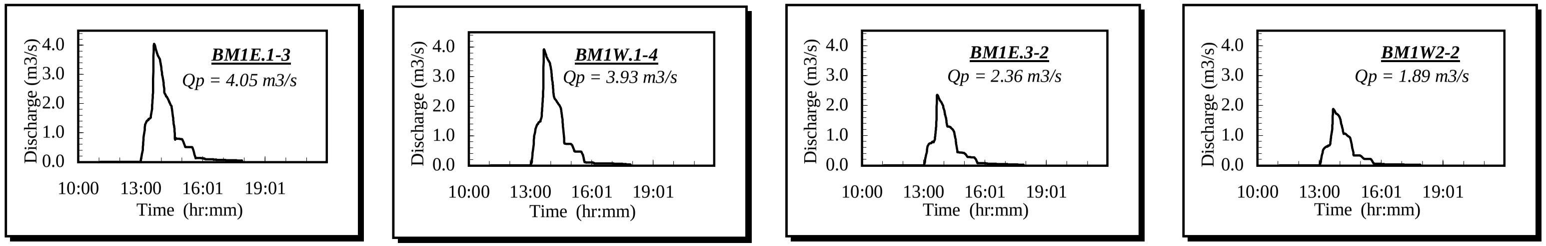
CASE 2A: BEN ME COC 1 (EAST AREA - PHASE I)

FIG. 4.17 (2/4) HYDRODYNAMIC SIMULATION RESULT FROM MOUSE



HYDRODYNAMIC MODEL NETWORK

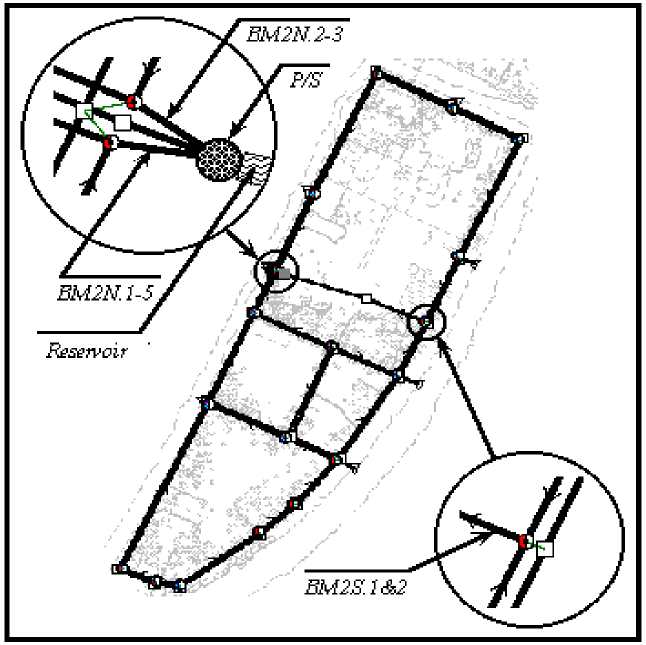
RESERVOIR WATER LEVEL AND PUMP OPERATION



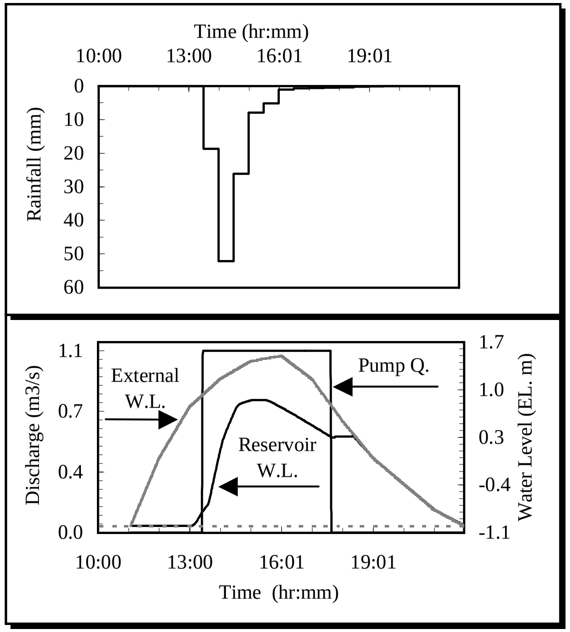
DISCHARGE HYDROGRAPHS TO RESERVOIR

CASE 2B: BEN ME COC 1 (EAST & WEST AREA - PHASE II)

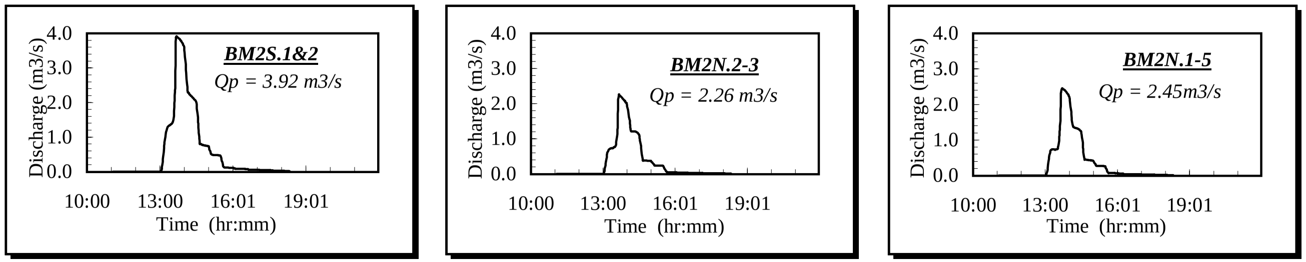
FIG. 4.17 (3/4) HYDRODYNAMIC SIMULATION RESULT FROM MOUSE



HYDRODYNAMIC MODEL NETWORK



RESERVOIR WATER LEVEL AND PUMP OPERATION



DISCHARGE HYDROGRAPHS TO RESERVOIR

CASE 3: BEN ME COC 2 : (NORTH & SOUTH AREA)

FIG. 4.17 (4/4) HYDRODYNAMIC SIMULATION RESULT FROM MOUSE